must be prevented by mixing with them other substances, such as refractory earths, or metallic oxyds difficult to be fused.

The metallic calces which form the bases of the yellow colours are generally those of lead; as minium, the white calx of lead, or litharge, the white calx of antimony, called diaphoretic antimony: that called crocus metallorum is also employed. This regulus, pulverised and mixed with white oxyd, gives likewise a yellow. The following are the different compositions used: one part of the white oxyd of antimony, one of the white oxyd of lead (or two or three); these doses are exceedingly variable; one part of alum, and one of sal-ammoniac. When these matters have been all pulverised, and mixed well together, they are put in a vessel over a fire sufficient to sublimate and decompose the sal-ammoniac; and when the matter has assumed a yellow colour, the operation is finished.* The calces of lead mixed in a small quantity either with silex or alumine, also with the pure calx of tin, exceedingly white, give likewise yellows. One part of the oxyd of lead is added to two, three, or four of the other substances above mentioned. In these different compositions for yellow, you may use also oxyd of iron, either pure, or that kind which has been prepared with alum and vitriol of iron: you will then obtain different shades of yellow. From what has been said, you may vary these compositions of yellow as much as you please. Yellows require so little flux, that one or two parts, in general, to one of the colour are sufficient; saline fluxes are improper for them, and especially those which contain nitre. They must be used with fluxes composed of enamel sand, oxyd of lead, and borax, without marine salt.

(*To be concluded in our next number.*)

* This in colour-shops is called Naples yellow.

place which you wish to stain yellow, and to heat the article gently to give it the colour. You must not employ too strong a heat: the degree will easily be found by practice. When the article has been sufficiently heated, you take it from the fire and separate the coating of oxyd, which will be found reduced to a regulus: you will then observe the place which it occupied tinged of a beautiful yellow colour, without thickness. It is chiefly on transparent glass that this process succeeds best. Very fine silver filings produce the same effect: but what seemed to me to succeed best in this case, was sulphat of silver, well ground up with a little water, that it may be extended very smooth. From what has been said, it may readily be seen that this yellow must not be employed like other colours; that it must not be applied till the rest have been fused; for, as it is exceedingly fusible, and ready to change, it would be injured by the other colours; and as the coating of silver which is reduced must be removed, the fluxes would fix it, and prevent the possibility of its being afterwards separated. Working on glass is not attended with this inconvenience, because the silver-yellow is applied on the opposite side to that on which the other colours are laid.

Green.

Green is obtained directly from the oxyd of copper. All the oxyds of copper are good: they require little flux, which even must not be too fusible: one part or two of flux will be sufficient for one of oxyd. This colour agrees with all the fluxes, the saline as well as the metallic; which tends to vary a little the shades. I have already pointed out the method of employing these oxyds on raw enamel: were not that method only followed in this case, the oxyd of copper would extend,

and spread itself, like a cloud, beyond the limits prescribed for it.

A mixture of yellow and blue is also used to produce green. Those who paint figures or portraits employ glass composed in this manner; but those who paint glazed vessels, either earthen-ware or porcelain, employ in general copper green.

Independently of the beautiful green colour produced by oxydated copper, it produces also a very beautiful red colour; but I do not know that it is employed on enamel. This beautiful red colour, produced by copper, is exceedingly fugitive. The oxyd of copper gives red only when it contains very little oxygen, and approaches near to the state of a regulus. Notwithstanding the difficulty of employing this oxyd for a red colour, a method has been found to stain transparent glass with different shades of a very beautiful red colour by means of calx of copper. The process is as follows: You do not employ the calx of copper pure, but add to it calx of iron, which for that purpose must not be too much calcined; you add also a very small quantity of calx of copper to the mass of glass which you are desirous of tingeing. This glass at first must have only a very slight tinge of green, inclining to yellow. When the glass has that colour you make it pass to red, and even a very dark red, by mixing with it red tartar in powder, and even tallow. You must mix this matter well in the glass, and it will assume a very dark red colour. The glass swells up very much by this addition. Before it is worked it must be suffered to settle, and become compact; but as soon as it has fully assumed the colour it must be immediately worked, for the colour does not remain long, and even often disappears while working; but it may be restored by heating the glass at the flame of a lamp. It is exceedingly difficult to make this colour well; but when

it succeeds it is very beautiful, and has a great deal of splendour. By employing the calx of copper alone for the processes above mentioned you will obtain, when you succeed well, a red similar to the most beautiful carmine. The calx of iron changes the red into vermilion, according to the quantity added. If we had certain processes for making this colour, we should obtain all the shades of red from pure red to orange, by using, in different proportions, the oxyd of copper and that of iron. The calx of copper fuses argil more easily than silex: the case is the same with calx of iron. If you fuse two or three parts of argil with one of the oxyd of copper, and if the heat be sufficient, you will obtain a very opake enamel, and of a vermilion red colour: the oxyd of copper passes from red to green through yellow; so that the enamel of copper, which becomes red at a strong heat, may be yellow with a weaker heat. The same effect may be produced by deoxydating copper in different degrees: this will be effected according as the heat is more or less violent. The above composition might, I think, be employed to give a vermilion red colour to porcelain. The heat of the porcelain furnace ought to be of sufficient strength to produce the proper effect.

The calx of iron fused also with argil in the same proportions as the calx of copper, gives a very beautiful black. These proportions may, however, be varied.

Blue.

Blue is obtained from the oxyd of cobalt. It is the most fixed of all colours, and becomes equally beautiful with a weak as with a strong heat. The blue produced by cobalt is more beautiful the purer it is, and the more it is oxydated. Arsenic does not hurt it. The saline fluxes which contain nitre are those best suited to it: you add a little also when you employ that flux which con-

tains a little calcined borax or glass of borax, though you may employ it also with that flux alone.

But the flux which, according to my experiments, gives to cobalt blue the greatest splendour and beauty, is that composed of white glass, (which contains no metallic calx,) of borax, nitre, and diaphoretic antimony well washed. When this glass is made for the purpose of being employed as a flux for blue, you may add less of the white oxyd of antimony: a sixth of the whole will be sufficient.

Violet.

Black calx of manganese, employed with saline fluxes, gives a very beautiful violet. By varying the fluxes, the shade of the colour may also be varied: it is very fixed as long as it retains its oxygen. The oxyd of manganese may produce different colours; but for that purpose it will be necessary that we should be able to fix its oxygen in it in different proportions. How to effect this, as far as I know, has never yet been discovered.

These are all the colours obtained from metals. From this it is evident that something still remains to be discovered. We do not know what might be produced by the oxyds of platina, tungsten, molybdena, and nickel: all these oxyds are still to be tried; each of them must produce a colour, and perhaps red, which is obtained neither directly nor with facility from any of the metallic substances formerly known and hitherto employed.

General Remarks.

Those who paint on enamel, on earthen-ware, porcelain, &c. must regulate the fusibility of the colours by the most tender of those employed, as for example, the

purple. When the degree which is best suited to purple has been found, the other less fusible colours may be so regulated, (by additions of flux,) when it is necessary to fuse all the colours at the same time, and at the same degree of heat.

You may paint also in enamel without flux; but all the colours do not equally stand the heat which must be employed. If the enamel, however, on which you paint be very fusible, they may all penetrate it. This manner of painting gives no thickness of colour; on the contrary, the colours sink into the enamel at the places where the tints are strongest. To make them penetrate, and give them lustre, a pretty strong fire will be necessary to soften the enamel and bring it to a state of fusion. This method cannot be practised but on enamel composed with sand, which I call enamel sand, as already mentioned. It may be readily seen, also, that the colours and enamel capable of enduring the greatest heat, will be the most solid, and the least liable to be changed by the air. An account of the method of employing and baking enamel may be found in various works, and may be learned also by seeing the operations of enamellers.

NO. 80.

On the Preparation of Amber Varnish, and the Application of it to different Kinds of stained Wood. By NILS NYSTROM.*

AS furniture of foreign wood is in general expensive, the use of the indigenous kinds of wood ought not to be neglected, especially when they are of a compact texture,

* Tilloch, vol. 7, p. 232. From the *Transactions of the Academy of Sciences at Stockholm for the year* 1797.

have a fine grain, and are sufficiently hard. Furniture made of these kinds of wood, after it has been well polished, may be stained of different colours, and then done over with linseed oil and amber varnish.

As my principal view, however, was to try in what manner different kinds of wood could be stained so as to retain their colour longest, and in what manner mahogany could be best imitated, I applied such a composition as I thought would best answer the purpose on the twelve following kinds of wood; namely, elm, oak, red and white beech, maple, pear-tree, wild hawthorn, white beam-tree, ash, alder, birch, and pine. Of these the maple, birch, alder, and white beech, when stained with a solution of iron, had the greatest resemblance to mahogany. The appearance of the other kinds was various, according to the diversity of their colour and veins, and according as they were more or less porous, and imbibed a greater or less quantity of the stain.

The amber varnish prepared in different places is not always of equal goodness. This is owing to two causes: 1st, The careless manner in which the amber is melted; 2nd, Because the linseed oil, being too much or too little boiled, acquires, in a greater or less degree, a drying property. A proof of amber varnish being good, is, if, when applied on any article in an apartment of the common temperature, it becomes dry within from twelve to twenty-four hours.

By the experiments which I made, I have found that the following process for preparing it is the best:—Put pounded and sifted amber into a pan of cast iron with a flat bottom, and let the amber be spread out at most to the thickness of an inch. Place the pan in an upright position over an uniform coal fire, and let it remain till the amber fuses and becomes liquid; then pour it out on a cold plate of copper or iron. When the amber has cool-

ed, break it into pieces; and if it has a bright blackish-brown appearance on the fracture, and weighs about one-half of what it did before being melted, you may be certain that it is proper for the intended purpose. Particular attention must be paid to this circumstance; for, if the amber is fused too little, so that part of it remains unmelted, it will not be dissolved by the varnish; and if the operation be performed with a continued and strong heat, it will be burnt and unfit for use.

When the amber is kept over a weak fire it will not melt, but becomes a sort of blackish brown incrustation, which also may be employed for varnish provided it has not been too much or too little evaporated: it will be in the best condition when you obtain half a pound from a pound. If the amber is too little evaporated, it must be again put into the pan till it be reduced to the proper weight. The same thing is to be observed when you melt it; but the parts which are not fused must be picked out, in order to be afterwards also melted.

I have found that a pan with a flat bottom is better than one with a round bottom, because the melting or evaporation is effected sooner in the former than in the latter; for in the latter the amber lies thick in the middle, and is burnt at the bottom and sides before it can be brought to melt or evaporate.

It is not necessary, for making varnish, to pick out pure and transparent amber, but only the common yellow small fragments, which may be procured for half the price of that in lumps. The earthy part, which is found in amber not of the clearest kind, separates itself from the warm varnish when it is suffered to stand some time before it is decanted.

Method of preparing Linseed-Oil Varnish.

One pound of well pulverised and sifted litharge, four ounces of finely pounded white vitriol, and one quart of linseed oil. Put these ingredients into an iron pan of such a size that it may be only half full; mix them well together, and boil them till all the moisture is evaporated, which may be known by a pellicle being formed on the surface, or by the barrel of a quill bursting when thrust to the bottom of the boiling varnish. Then take it from the fire and pour off the clear liquid, taking care to keep back the thick part which has deposited itself at the bottom. While boiling, it must be stirred several times round, that the litharge may not fall to the bottom; but you must not stir it constantly, else superfluous litharge would be dissolved, and the varnish become too thick.

The composition of amber varnish consists of half a pound of melted or roasted amber, one pound and a half of linseed-oil varnish, and two pounds of turpentine oil. The amber and linseed-oil varnish are to be mixed together in a deep cast-iron pan, of such a size as to be only one-third full, and to be kept over a slow fire till the amber is dissolved, which may be known by its swelling up: the operator, therefore, must have at hand a large copper or iron vessel, that the varnish may be held over it in case it should rise above the sides of the pan, and to prevent the loss that would thereby be occasioned. When the varnish is dissolved, the pan must be taken from the fire; and when the mixture has cooled, the turpentine oil is to be poured into it, continually stirring it. Then let it stand some time, that the course undissolved particles may deposit themselves at the bottom; after which pour off the clear varnish, and, having strained it through a piece of linen, put it into bottles for use.

In boiling the varnish, care must be taken that it may not boil over or catch fire. Should this happen to be the case, it must not be extinguished by water; for this mode would occasion such a sputtering, that the operator would be in danger of having his face bespattered with the boiling varnish. The best method, therefore, is to cover the vessel in such a manner as to exclude the air, and with any thing that may be at hand, such as a piece of wood, plate of iron, or any thing else that may cover the vessel and extinguish the flame.

1. *Iron Stain.*

Eight ounces of iron-filings and thirty-two ounces of common aquafortis. The aquafortis must first be mixed with sixteen ounces of water in a stone jar, and then a few of the filings are to be added, and well stirred round with an iron or wooden spatula. This preparation must be made in a chimney, because the solution is attended with heat, effervescence, and the disengagement of noxious vapours: it is of importance, also, that the jar should be of such a size as to prevent the matter from running over. After the greater part of the iron has been dissolved in this manner, the solution will be of a yellowish brown colour. As soon as the mixture has cooled, pour it into a bottle placed in a pan, and let it stand a day or two, without being corked, over a warm stove; during which time shake the bottle frequently. The bottle being then suffered to cool, pour into it one pound three quarters of river water, stirring it well round, and leave it at rest for a few minutes till the undissolved part sinks to the bottom: then pour the solution into another bottle, and cork it up for use.

When this preparation has been carefully made according to the above directions, you obtain a yellowish brown solution, which may be employed for staining. In

case too much water, however, has been at first employed, or too weak aquafortis, the colour becomes dark brown; and therefore the addition of the aquafortis must be increased in that proportion which the solution requires, observing the above rules.

This stain may be applied to all kinds of wood except oak, which contains too much astringent matter, and therefore on the first application becomes almost black. It communicates to the various kinds of wood different colours, according as it is applied in greater or less quantity; such as yellow, yellowish brown, and dark brown, with reddish brown stripes or spots.

As far as I have been able to ascertain by experience, this stain is one of the most durable; it withstands the air and rays of the sun without changing its colour. I have specimens of it which have been exposed four years continually to the sun and air, without their colour being altered.

2. *Brazil Wood Stain.*

Eight ounces of real Brazil wood, four ounces of alum, and four ounces of finely pounded reddle or red ochre. Pour over this mixture a proper quantity of water; and, having suffered it to remain in that state twenty-four hours, boil it to a fourth part; then strain it through a piece of linen cloth, and preserve it in a glass bottle for use.

If one pound of the stain No. 1, be diluted with three pounds of water, immerse some pieces of wood in it, and deposit the whole in a warm place: the wood will imbibe the liquid to the depth of a quarter of an inch, and in the soft parts of the wood it will penetrate still further.

It must however be remarked, that the staining liquor must be diluted with a greater or less quantity of water,

according as the wood is darker or whiter, more or less astringent. The wood must often be turned, and care must be taken that it may acquire an uniform and proper colour; after which it may be taken out and dried.

The like process must be followed when the stain, No. 2, is employed, only that the same attention is not necessary in regard to obtaining an uniformity of colour. This mode, however, can be used only on a small scale.

Method of staining Articles of White Wood with the above Compounds.

Rub the stain No. 1, over the wood with a piece of sponge five or six times till it acquire a proper mahogany colour. While the liquor is applied, shake it or stir it carefully round, that the iron ochre, which has deposited itself at the bottom, may be well mixed with the ferruginous solution that stands over it; and between each application of the liquid the wood must be suffered to become thoroughly dry. After this, it must be rubbed over once or twice with linseed oil, letting it dry before the oil is applied the second time. The more the wood is soaked with linseed oil, so much the better; as in that case it does not imbibe so much of the amber varnish, which only deposits itself on the surface, and gives it a bright appearance.

When the wood has been thus rubbed over, and well dried, the amber varnish must be applied in an uniform manner with a sponge once or twice, or until it acquires a smooth shining surface. If the wood has been well done over with linseed oil, one application of the varnish only will be necessary; but on bedsteads, chests of drawers, chairs and other furniture which are exposed to more use,

it must be applied several times, and each time they must be well dried.

After the application of the varnish, if any inequalities or lumps appear, they may be removed, after the article is dry, by means of a carpenter's rush, and a fresh coating of varnish applied to the place. For applying the varnish, I have found it most convenient to use a sponge; as by these means it can be laid on in a much more uniform manner than by a painter's brush, which, for the most part, leaves stripes or loose hairs behind it. The sponge with which the varnish is laid on, must, between each application, be well shut up in a wide-mouthed bottle, that the varnish it has imbibed may not be dried by the air, which would render it hard, and unfit for use.

The same process is to be followed with the stain No. 2. When applied to knotty birch wood or alder, the wood becomes undulated, because the liquor extends itself crosswise. The case is the same with fat and knotty pine wood or fir; for the resinous spots do not so strongly attract the stain as the other parts. This, however, makes the appearance of the wood not disagreeable.

The amber varnish may be applied also over almost all oil colours except blue, which it would change to green. It is attended with this advantage, that it never cracks; as is the case in general with lack varnishes, and those prepared with spirit of wine.

I have found, also, that this varnish is proper for being applied on real gilding, because it makes no perceptible alteration in the colour; especially when laid on thin, and in an uniform manner. This object also is obtained, that the gilding may be cleaned by means of spirit of wine, or of soap and water, without sustaining any injury. For

false gilding, however, it is improper; as it attacks it, and makes it rusty and green.

I have applied this varnish, in the above manner, to bed-posts, drawers, tables, and chairs, which at the end of two years were little or nothing changed in their appearance. When this varnish has become perfectly dry and hard, it withstands boiling heat and friction; and does not lose its splendour by the course of time, unless rubbed or scoured with sand. It prevents ink, or any other coloured liquid that may be spilt on furniture, from penetrating into the wood, and causes stains to be easily removed by washing with water. On this account, it is very proper for being applied on articles of mahogany. It renders the soft kinds of wood much harder at the surface.

This varnish used in this manner would not be expensive, as eight ounces of it is sufficient for a common card-table. Should the table be scratched, the injured part may be easily repaired by a new coating of varnish; and if it be new varnished every four or five years, it will always retain a beautiful and bright appearance.

Tables and other flat articles which require a great deal of polishing, when the stain and linseed oil have been applied, may be rubbed with a piece of pumice stone before they are done over with the varnish. This pumice stone must be made flat on one side, and must be free from sand, so as not to scratch the wood. As the softer kinds of wood swell up, for the most part, when the stain is applied, and lose their smoothness, rubbing them in the above manner with pumice stone is the more necessary.

No. 81.

Method of giving the Grain and Hardness of Steel to Copper. By B. G. Sage.*

MARGRAFF and Pelletier have published their researches on the union of phosphorus with different metallic substances: the French chemist has improved this process, and it was by repeating and varying his experiments that I discovered that the surest and speediest means of phosphorizing copper was to take the metal under the metallic form, to fuse it with two parts of animal glass, and a twelfth of charcoal powder; but it is essential that the copper should present a great deal of surface,—an advantage obtained by taking shavings of that metal, which are placed in strata with animal glass mixed with charcoal powder. I expose the crucible to a fire sufficiently strong to fuse the animal glass. There is then formed phosphorus, the greater part of which burns, while another combines with the copper, in which it remains incarcerated till no more is disengaged, though kept in fusion for twenty minutes under the animal glass which has not been decomposed.

When the crucible has cooled, and is broken, the phosphorated copper is found in the form of a gray brilliant button under the glass, which has passed to the state of red enamel. On being weighed, it is found that by this operation its weight has been increased a twelfth.

If the phosphorized copper, when fused, falls on a plate of polished iron, it extends itself over it in the form of plates differently figured, which exhibit the play of colours of a pigeon's neck.

* Tilloch, vol. 20, p. 159. From the *Journal de Physique*, Messidor, an. 12.

The phosphorized copper is much more fusible than common copper: it may often be fused under charcoal powder without losing any of its properties.

The same phosphorized copper, when exposed a long time under the muffle, separates only with great difficulty from the phosphorus.

The copper thus combined with phosphorus acquires the hardness of steel, of which it has the grain and the colour: like it, it is susceptible of the finest polish; it can be easily turned; it does not become altered in the air. I have kept buttons of polished phosphorized copper in my laboratory for fifteen years, without their experiencing any alteration. The copper emits no smell when rubbed. Were it ductile, it would be of the greatest utility, since no fat bodies seem to have any hold of it.

In the phosphorization of copper there is only a part of the animal glass decomposed, because a quantity of charcoal necessary to phosphorize the whole acid has not been employed: but it is necessary that this should be the case in order that the vitreous scoria should be sufficiently fluid for the phosphorus to be disengaged and to collect itself readily.

The dark red enamel which is formed in this experiment may be employed with advantage for porcelain and enamels, as this red does not alter in the fire.

Copper can combine with phosphorus only in the dry way. If a cylinder of phosphorus be put into a solution of nitrate of copper diluted with four or five thousand parts of water, copper under the metallic form will be found at the end of eight days crystallized and ductile, forming a case to the cylinder of phosphorus.

No. 82.

The Art of moulding Carving in Wood. By LENORMAND, *Professor of Natural Philosophy in the Central School of the Department of Tarn.**

INGENIOUS or curious men are often thwarted in the execution of their projects by the difficulty of finding in the places where they reside workmen capable of assisting them in the articles for which they may have occasion. Small towns in particular furnish only indifferent workmen; and besides, they do not contain artists of every kind. Good carvers, for example, reside only in large towns; and these even are not very common. I had seen plaisterers supply the want of good modellers by incrusting in their decorations plaister moulded on excellent models. I therefore conceived that it might be possible to mould carving in wood, to be afterwards applied to cabinet-makers' work. This idea I did not at first carry into execution; but two or three years after, having occasion for some pieces of carving, I invented a new art,† as will be seen by what follows. Necessity rendered me industrious, and I at length accomplished my object.

Wishing to obtain a case for a pendulum clock I had constructed, I drew a plan of it; and presented it to an excellent cabinet-maker in the small town in which I resided. He would undertake only the plain work, and referred me for the execution of the carving to Toulouse or Bourdeaux. I was sensible how difficult it would be to get the carving of the different pieces executed at a distance, and particularly within the required time; and

* Tilloch, vol. 16, p. 247. From the *Bibliothèque Physico-Economique*, June 1803.

† This art is not new; but the experiments of the author may furnish useful hints to artists.—TILLOCH.

how expensive it would be to transport such a case, which might also be damaged by the way. I told him that I would myself undertake the carving of the laurel and oak foliage which I had placed in the plan, provided he would undertake the remaining part. Fearing, however, that my carving would not correspond to his work, and might tend to degrade it, he was unwilling to undertake any thing till I had shown him a specimen of my labour—a proposal to which I consented.

I was well aware that very hard wood, such as box, might be moulded by putting it under a press in copper moulds, after having subjected it to certain preparations: but for this purpose very expensive moulds, an excellent press, &c. are required, which occasions considerable expense, and by this method bas-reliefs only can be executed. But the art I am about to describe requires only cheap materials with very little practice, and affords the means of making not only figures in relief, but even the most difficult objects of sculpture.

In the town where I resided I found one of those Italians who employ themselves in moulding plaister figures. I caused him to make such moulds as I had occasion for, and which were copies from the best masters. I succeeded perfectly in moulding my garlands in walnut-tree wood; and I showed them to my cabinet-maker, who took me for an able sculptor. He constructed the case, applied to it the foliage I had made, and neither he nor any person who saw it had the least suspicion of the method I had employed. All believed that the ornaments had proceeded from the chisel of an able carver. Since that time I have moulded for my friends bas-reliefs, trophies, &c. with wood of every kind. I shall now describe my process.

Process.

I MADE very clear glue with five parts of Flanders glue and one part of fish glue or isinglass. I dissolved these two kinds of glue separately in a large quantity of water, and mixed them together after they had been strained through a piece of fine linen to separate the filth and heterogeneous parts which could not be dissolved. The quantity of water cannot be fixed, because all kinds of glue are not homogeneous, so that some require more and some less. The proper degree of liquidity may be known by suffering the mixed glue to become perfectly cold: it must then form a jelly, or rather a commencement of jelly. If it happens that it is still liquid when cold, a little of the water must be evaporated by exposing the vessel in which it is contained to heat. On the other hand, if it has too much consistence, a little warm water must be added. In a word, the proper degree will be ascertained by a few trials.

The glue thus prepared is to be heated till you can scarcely endure your finger in it: by this operation a little water is evaporated, and the glue acquires more consistence. Then take fine raspings of wood or sawdust, sifted through a fine hair-sieve, and form it into a paste, which must be put into moulds of plaister or sulphur after they have been well rubbed over with linseed or nut-oil, in the same manner as when plaister is to be moulded. Care must be taken to press the paste in the mould with your hand, in order that it may aequire all the forms of the mould: then cover it with an oiled board, and, placing over it a weight, suffer it in that manner to dry. The desiccation may be hastened and rendered more complete by a stove. When the impression is dry remove the rough parts, and if any inequalities impression hind they must be smoothed; after which the remain be.

may be affixed with glue to the article for which it is intended. Then cover it with a few strata of spirit of wine varnish, as is done in general in regard to carved work, or with wax in the encaustic manner. It requires much attention to discover that such ornaments are not carved in the usual manner. Gilding may be applied to them with great facility. This operation is exceedingly easy; nothing is necessary but moulds; and with a little art the ornaments may be infinitely varied.

I tried also to mould figures, and completely succeeded. These, however, require more care. I first make a paste, similar to the former, with very fine sawdust, and place a stratum, of about two lines in thickness, on every part of the mould; after which it is left to dry almost entirely. In the mean time I prepare a coarse paste with coarse sawdust which has not been made to pass through a fine but a coarse sieve, and instead of Flanders glue I employ common glue, which is less expensive, adding to it a sixth of fish glue. I first put together two parts of the mould, after introducing into the joints a slight stratum of the fine paste, which I make very clear and apply with a small brush. I fill up the vacuity between the two pieces with coarse paste. I then apply the third piece as I did the second, and so on until the whole are adjusted, always filling up the vacuities with coarse paste. I suffer the whole to dry in the mould, and obtain a figure in relief of solid wood executed with all the delicacy of plaster figures. Care must be taken to remove with a sharp knife, or a small file, the prominences formed by the joinings. If the figure be not suffered to dry too much, these prominences may be easily removed with the point of a sharp penknife. It will be necessary to learn the art of determining the proper degree of desiccation; for if the figure be taken from the mould before

it is properly dried it will become warped, and if it be too dry it cannot be corrected but with a file, which is tedious and laborious, whereas if the proper moment be seized the paste may be cut like wax; especially if the sawdust has been fine which is necessary for the exterior strata. The figures may then be completely dried in a stove, by which means they will acquire a degree of desiccation and solidity hardly to be conceived. Figures thus moulded may be bronzed or varnished: they will then be unalterable by the effects of moisture or dryness.

I have already said that Flanders and not common glue ought to be employed for the exterior strata, because this glue is almost colourless;* whereas the other, being dark-coloured, gives too obscure a tint even to walnut-tree wood. Being desirous to try whether my moulded figures would be unalterable by the effects of moisture or dryness, I made the following experiments:

Experiment I.

I EXPOSED in a large bell-glass filled with atmospheric air two figures, one of which was varnished and the other not. I placed under the bell Saussure's hygrometer and a capsule filled with water, after having moistened the sides of the bell. The air was soon saturated with water, and the hygrometer marked 100 degrees. I observed no alteration whatever in the varnished figure, and the other exhibited no other sensible alteration than a commencement of solution in the glue, so that on applying my finger to its surface it was found to be somewhat viscid; in a word, the figure was not in the least warped.

* When this cannot be had, a glue fit for the purpose may be made by boiling shreds of parchment in common water till dissolved.—TILLOCH.

Experiment II.

I THEN introduced my two figures and the hygrometer into another very dry bell, under which I had placed a capsule filled with calcined potash. The moisture of the air by which the figures were surrounded was soon absorbed, and the hygrometer indicated zero. In order to ascertain whether the whole moisture imbibed by the unvarnished figure was entirely dissipated, I left every thing *in statu quo* for four hours, the hygrometer still indicating zero. I then took out the two figures, neither of which had experienced the least alteration.

Experiment III.

I REPEATED the first experiment with a view to cause the two figures to absorb as much moisture as possible; and when the hygrometer marked 100 degrees I took them from the bell, and suddenly introduced them into a stove the heat of which was 50 degrees of Reaumur. The unvarnished one became dry without cracking, and the other showed a little softening in the varnish. This effect I ascribed to the imperfect desiccation before the experiment, for the softening was more considerable than is generally the case when a varnished body is exposed to heat.

These experiments appeared to me sufficient to induce me to conclude, that sculpture in moulded wood, according to the process here described, is unalterable by moisture or drought, for in our climates the thermometer never rises to 50 degrees. Such sculptured figures have the solidity of wood, and are even preferable to it; for a slight blow given to wood, if cut across the fibres, will detach some of the parts; whereas figures formed of artificial wood, if I may be allowed the expression, are

homogeneous in all their parts, and are not so easily broken.

Besides the advantages which this invention on the first view exhibits, it offers others which may be of great utility in our arts and manufactures.

1st, In the large manufactories of mirrors the ornaments in general are in a very bad taste and miserably executed, because the carvers are very ill paid. If this new method be adopted, sculptors would pay more attention to their first work: they would mould their ornaments in plaster or in sulphur, then take a multitude of copies with the greatest facility, and these ornaments would add to the value of our furniture.

2d, Inlayers would make much more elegant works by employing pastes of different coloured woods, which might be managed with greater ease than the thin pieces of coloured boards which they employ. I am now engaged with some experiments on this subject. My intention is to make small tablets to imitate mosaic. I shall communicate the result to the public as soon as my experiments are terminated.

No. 83.

*A Memoir concerning several indigenous Plants, which may serve as a Substitute for Oak Bark, and for certain foreign Articles in the Tanning of Leather.**

THE object of this memoir is to show how the destruction of trees, and particularly of oak-trees, which are so valuable, may in great part be prevented. A great consumption of them is caused by the tanneries.

* Tilloch, vol. 17, p. 140. From the *Transactions of the Royal Society of Berlin*, vol. 10.

A discovery has been made last summer, which will contribute to the preservation of the trees, and to the continuation and even to the increase of the tanneries. Eight new sorts of leather have been prepared and tanned without any bark at all, and with materials of which we shall give a detailed account. By using these articles, there is a saving, not only of bark, but likewise of several foreign drugs, which are generally used in tanning. It is surprising that the experiments on which this discovery is founded have not been made sooner, as they are exceedingly easy, and the various methods practised by other nations, and even by the most savage ones, for making leather, pointed out the way to them. In fact, be it owing to the want of bark, or to old practice, it is usual in several contries to tan leather with leaves, roots, fruits, and juices. We shall not enter now into all the historical details of which the subject is susceptible; but it is proper, however, to give a sketch of them.

Some of the Calmuc Tartars, that rove about towards the great wall of China, tan the skins of their horses with sour mares milk. In Persia, Egypt, and some countries bordering on Africa, goats' skins are tanned with the astringent and leguminous fruit of the true acacia, which is gathered before it is ripe. In several parts of the Turkish empire the same skins are made into Morocco leather by the means of galls. The green nuts of the turpentin tree, and, according to some, even the leaves, as likewise those of the lentisk tree, serve for the same purpose in many parts of the Levant. The *smak*, or budles of the leaves and young branches of sumach, is very well known, and is used in all countries for the making of Cordovan leather. It is also well known that in several provinces of Italy, Spain, and France there are actually used several plants, which

may be called *plantæ coriariæ*, such as the *arbutus*, the *celtis*, the *tamarisk*, the *rhamnus*, the *rhus myrtifolia*, &c. In Sweden they use the bark of one of the small species of mountain sallow, as also a wild plant known by the name of *uva ursi*. The Silesians use in tanning a sort of myrtle called *rausch*. But for tanning, nothing is used in Germany but the bark of oak and birch tree, with some acorn shells; and as to the making of Cordovan and Morocco leather, they use sumach and galls, as almost all other nations do.

When the eight new methods of preparing leather already alluded to shall be once introduced, all the other articles will be no longer necessary; and there will be found in his majesty's dominions the plants fit for tanning, among which are some that will serve also for dyeing skins. We have already about sixty species of such plants; and if, after having made an exact choice, there should remain but twenty of them, our object will be attained, both as to the preservation of wood, and the doing without foreign articles.

Skins differ from each other according to the species of animals, as likewise according to their age, food, and the climate they belong to; whence it follows, that there must be various methods of tanning, all which can be reduced to the three methods called in Germany *weiss-gahr* (white preparation), *semisch-gar*, (soft preparation,) and *loh-gahre* (tanning). I omit parchment, shagreen, and what concerns skinneries.

The first preparation is the same in these three methods. When the skins are well cleansed, lime, or sand and salt are made use of to take off the hair, and then they are washed several times, &c.

But the following part of the process is not the same in these different methods. We shall omit at present the two first methods, which require several ingredients taken

from the three kingdoms of nature, such as alum, common salt, raw tartar, bran, meal, and fish oil; but it is necessary to enter into some details with regard to the third, in which vegetables alone are used, that serve to make a sort of ley, by means of which the tanning is completed.

This third method can be subdivided again into four sorts, according to the four principal sorts of leather that are prepared with the help of different vegetables, viz. 1. Common leather; 2. Cow's leather; 3. Cordovan; 4. Morocco leather.

Every vegetable ley fit for making leather is either cold or hot.

The cold process is the simplest and easiest, but, at the same time, the slowest; it is used for the coarsest and heaviest sort of skins, which are put in holes, or in wooden vessels, with oak or birch bark.

The method of tanning with hot leys is often very troublesome, but it is more expeditious than the former one. Some sorts of leather require three weeks; others eight, twelve, or fifteen days. From twenty-four to thirty-six hours are sufficient for Cordovan; Morocco leather takes seven or eight hours, and sometimes from sixteen to twenty. This method is as follows: The ley is poured into wooden vessels, together with hot water; the skins are put into it, and stirred often. After eight days time the water is thrown out, heated again, poured upon fresh ley, and the whole is poured upon the skins. This operation is continued and repeated until the vegetable parts have penetrated the substance of the skins so as to change them into leather; which is then dried, and given over to the curriers.

We may remark here, that cow leather cannot be made as cheap with us as in Russia; and that the scented sort called *cuir de Roussi* derives that property from two em-

pyreumatic oils, which it is rubbed with in the preparing of it.

As to Cordovan and Morocco leather, they are made of goats' skins, and prepared, the one with sumach, the other with galls.

We have said enough concerning the general principles of tanning, so as to throw a light upon what relates to the plants that can be made use of in it.

There is abundance of these plants in our country, and eight new methods of preparing leather with them have been discovered. They have been treated of in a memoir that was read before the academy on the 5th of last December. The author of this memoir, and the maker of these new sorts of leather, is M. Klein, a native of Nauen. He requested I should show him all the plants that I thought fit for tanning. I have mentioned the names of these plants to the academy, and specified their properties. They are all indigenous plants, very common and abundant, and which have been heretofore considered as noxious weeds, as the utility of them was not known; and accordingly, their being used in tanning will not be in the least hurtful to private economy. M. Klein has collected a considerable quantity of these species of plants; and among the eight sorts of leather that have been made with them there is very fine Cordovan prepared without sumach, and two sorts of calf-skin, tanned only with leaves of trees.

These coriaceous plants grow in almost all deep places and marshy grounds; there are some of them found also in sandy soil, on hills, and in woods. The hay which they yield is the coarsest of all, and in very small quantity; the cattle never touch it, except when they are starving with hunger. Such plants spoil good meadows. A great quantity of them is to be had, particularly near lakes and large ponds; and it is

no exaggeration to say that there are sixty species of them.

It is very easy to discover the chemical principles in virtue of which these plants are fit for tanning, if one has a knowledge of those of sumach, galls, and different sorts of bark. With regard to this point, the plants may be divided into two principal classes. The principles that are chiefly to be considered are found generally in all of them; they are of a *fixed*, but still *active*, *terreo-gummy*, or *terreo-resinoso-gummy* nature. Besides these common principles, some other very active ones exist in some of these plants, in a greater or less quantity; and this is what constitutes the difference that we establish between the plants that can be used in tanning.

Those of the first sort have no smell, or at most a very weak one, but they have a very sharp and astringent taste. They contain only the active and fixed principles which we have mentioned, or at most an inconsiderable mixture of oleo-inflammable parts, which give a weak balsamic smell to the water distilled from them, without any sharp or styptic taste. The proportion of these parts varies in the terreo-resinoso-gummy substance; but that which commonly exists in the greatest part of the coriaceous plants is such, that, for instance, in a pound of them the terreous parts constitute one-third, or even one-half; and the gummy principle about one-fourth or one-third, and in some as much as one-half, while the proportion of rosin is the smallest of all, being only from twenty to fifty grains, or at most a drachm and about twenty grains.

In the second sort of these plants we find, indeed, the above-mentioned fixed active principles, but not in the same proportion, because they are mixed with other principles both volatile and fixed, so as to constitute the smaller part of the whole compound. Besides the fixed

parts there exists in these substances an unctuous balsamic *oleoso-*, or *vaporoso-spirituoso-ethereous* principle. The volatile parts become soon disengaged from the rest, by the heat of the tanning ley, and evaporate, so that it is not at all times possible to discover any specific remains of them in the leather.

If we examine next what the fixed *terreo-gummy* or *terreo-resinoso-gummy* substance consists of, we shall obtain a very clear knowledge of it, either from considering the manner in which it is naturally produced, or by means of chemical experiments. This terreous matter is sometimes coarser, sometimes finer, sometimes in a greater and sometimes in a smaller quantity; and it contains an oily substance, or inflammable principle, attached to a light acid, of the nature of vegetable acid, but not caustic, like mineral acid. In analysing the fixed substance of coriaceous plants, we get by the alembic, out of a pound medical weight, nearly the following parts, in a proportion more or less different: 1. About an ounce and two drachms of a clear, empyreumatic, but not astringent phlegm; 2. About two ounces and five drachms of an acid yellowish liquor; 3. An ounce and somewhat more than six drachms of an empyreumatic oil. The *caput mortuum* often constitutes one half, or even more, and sometimes contains a portion of fixed alkaline salt. In dry fruits, juices, and bulbous roots, this proportion suffers some exceptions. It is easy to conceive that the knowledge of these component parts, of their respective quantities, and of their properties, which are well known to chemists, may lead to that of their effects, and of the manner in which they produce them. We shall be able then to distinguish a false tanning plant from a real one, or to lay aside such as are too weak for that purpose. There are some, for example, that are

much fitter for giving a fine dye to leather than for tanning it.

Nor is it difficult, after what we have said concerning the principles contained in the plants, to form an idea of their action upon skins, properly cleansed and macerated. The skins being left steeping in a decoction of these plants, or merely along with the coarse dust of them, undergo a change in the tissue of their parts, whereby they become leather. In this operation the soluble and active parts of the vegetables are separated from the coarse mass, with the help of air, evaporating moisture, water, work, and various degrees of heat. They remove imperceptibly from each other, and extend in every direction in a very gentle manner, which renders them fit for softly penetrating the substance of the skins, and producing gradually an alteration in them. It is easy to comprehend the effects which, in such a case, a gentle acid is capable of producing, when dissolved, mixed, and put in action with other particles highly volatile, oleoso-ethereous, and of great mobility. The skins are penetrated with these particles, and with those which we have called terreo-resino-gummy, as if with a sort of balsam, and are thereby condensed into leather. But as it is not our intention to enlarge upon the theory of tanning, we shall confine ourselves to our object, which is the indication of tanning plants, and shall mention another property of them, whereby they are plainly distinguishable from all others. This property occurs in their dust, or in a decoction of them, when mixed with copperas (vitriol de mars).

Take then these plants, and reduce them into dust, which you will throw into a solution of copperas; or put some copperas into an infusion or decoction of the plants which has been previously filtrated. The colour produced by this mixture is sometimes reddish or of a dark

red, and sometimes blue or black. The cause of this phenomenon is known to chemists, who know also how to make these decoctions or infusions transparent, and to make the colours disappear, by pouring into them, drop by drop, a sufficient quantity of oil of vitriol.

The properties of these plants being thus sufficiently ascertained, and there being the greatest plenty of them in the country, it remains now for the connoisseurs to extend the use of them, and to apply them further to the advantage of our national manufactures.

A List of the Plants that have been used in the Experiments on Tanning.

The number of plants fit for tanning is much greater than that of those in the following list; and it has been observed that, if they be gathered at proper seasons, they can be used for the preparing of all sorts of skins, both coarse and fine. The best of them are such as have the greatest quantity of a coarse, astringent, and acid substance. They are also the fitter for penetrating the skins, in proportion as they contain a greater portion of aromatic and spirituous parts, and are possessed of an essential ethereous oil. On the contrary, the inferior species of them are those whose substance is principally composed of fat or mucilaginous parts, which do not make so strong an impression on the skins, and can scarce serve for tanning the most tender ones.

Salicaria *vulgaris purpurea, foliis oblongis.* Tourn. Instit. 253. Lysimachia spicata purpurea, fortè Plinio. C. B. pin. 246. Purple-flowered loosestrife.

Ulmaria; Clus. Hist. 198. I. B. III. 488. Regina prati. Dodon. Pempt. 57. Queen of the meadows.

Comarum; Linn. Gen. pl. ed. 5. 563. Quinquefolium *palustre rubrum.* C. B. pin. 326. Red marsh cinquefoil.

Filix *ramosa major, pinnulis obtusis, non dentatis.* C. B. pin. 357. Filix fœmina offic. et Dodon. Pempt. 462. Common brackens, or female fern.

Filix *non ramosa, dentata.* C. B. pin. 358. Filix mas offic. et Dodon. Pempt. 462. Common male fern.

Filix *palustris maxima.* C. B. Prodr. 150. Water-fern.

Filix *mas aculeata, major et minor.* C. B. Prodr. 151.

Persicaria *salicis folio, potamogeton angustifolium dicta.* Raj. Hist. 184. Arsmart.

Persicaria *acida Jungermanni.* Water knot-grass.

Bistorta *major, radice minus vel magis intorta.* C. B. pin. 192. Snake-weed.

Tormentilla *sylvestris.* C. B. pin. 326. Wild tormentil.

Pimpinella *sanguisorba major.* C. B. pin. 160. Large wild pimpernel.

Caryophyllata *vulgaris.* C. B. pin. 321. Common avens, or herb bennet.

Caryophillata *aquatica, nutante flore.* C. B. pin. 321. Water avens.

Anserina *offic. argentea.* Dod. Pempt. 600. et *Potentilla.* I. B. II. 398. Goose-grass.

Quinquefolium *majus repens.* C. B. pin. 325. Large cinquefoil.

Quinquefolium *minus repens luteum.* C. B. pin. 325. Spring cinquefoil.

Quinquefolium *folio argenteo.* C. B. pin. 325. Satin cinquefoil.

Horminum *pratense, foliis serratis.* C. B. pin. 238. Clary.

Agrimonia *offic.* Agrimony.

Equisetum *arvense, longioribus setis.* C. B. pin. 16. Horse-tail.

Equisetum *palustre, longioribus setis.* C. B. pin. 15. Marsh horse-tail.

Alchemilla *vulgaris.* C. B. pin. 319. Common lady's mantle.

Muscus *pulmonarius,* sive Pulmonaria offic. Lob. Ic. p. 248. Pulmonaria arborea, Muscus quernus. Oak moss.

Lysimachia *lutea major, quæ Dioscoridis.* C. B. pin. 245. Yellow wood-loosestrife.

Vaccinium; Rivini. *Vitis idæa, foliis oblongis crenatis, fructu nigricante.* C. B. pin. 470. Black-worts—in Irish *Fraochan.*

Vaccinium *foliis buxi, sempervirens, baccis rubris.* Rup. flor. Gen. p. 52. Red bilberry.

Rubus *vulgaris,* s. *fructu nigro.* C. B. pin. 479. Common Bramble.

Rubus *repens, fructu cæsio.* C. B. pin. 479. Dewberry.

Fragaria *vulgaris.* C. B. pin. 326. Strawberry.

Filipendula; I. B. II. 189. Saxifraga *rubra off.* Red Saxifrage.

Pervinca; Tournefort. Vinca pervinca offic. Clematis daphnoides *major, flore cerulæo.* I. B. II. 132. Periwinckle.

Sparganium *ramosum et non ramosum.* C. B. pin. 115. Burn-reed.

Filago; seu *herba impia.* Dodon. Pempt. 66. Common cudweed.

Gnaphalium *montanum flore rotundiore et longiore.* Tourn. Inst. 453. Mountain cudweed.

Geranium *sanguineum maximo flore.* C. B. pin. 319. Bloody crane's bill.

Geranium *batrachoides maximum, minus laciniatum, folio aconiti.* I. B. III. 477. Meadow crane's bill.

Plantago *latifolia incana.* C. B. pin. 189. Broad-leaved plantain.

——— *angustifolia major et minor.* C. B. pin. 189. Narrow leaved plantain, both great and small.

——— *latifolia sinuata.* C. B. pin. 189. All sorts of plantain.

Hypericum *offic. et Matthiol. vulgare.* C. B. pin. 279. Common St. John's wort.

It is proper to observe in this place, that only the herbs in flower, or even the flowers alone, of the preceding plants are to be used. Some of them are more weak than others, and accordingly must be used in a different way. But as to the following ones, their leaves and branches, as likewise the unripe fruits of them, the seeds, and even the roots of some of them, are all equally fit for tanning.

Frondes *vitis viniferæ.* The vine.

Prunus *sylvestris.* Wild plum-tree; its bark and unripe fruit.

Salix *vulgaris alba arborescens.* Common white willow; its leaves and twigs.

—— *caprea rotundifolia.* Common willow; its leaves, bark, twigs.

Rosa; sylvestris, variorum colorum. Wild rose-bush: its leaves.

Fagus. Beech. Bark and leaves.

Carpinus. Horse-beech. Bark and leaves.

Quercus. All sorts of oak. Leaves.

Betula. Birch-tree. Bark and leaves.

Alnus. Alder. Leaves.

Mespilus; *species sylvestris vulgaris.* Wild medlar. Leaves, twigs, unripe fruit.

Ledum *rosmarini folio.* Wild rosemary.

Cornus *sylvestris mas.* Wild cornel tree. Leaves, twigs, stones.

Acetosa *pratensis.* Sorrel. Root. Seed.

Lapathum *maximum aquaticum.* Large water-dock. Root, leaves, seed.

Lapathum *folio acuto plano.* C. B. pin. 115. Sharp-pointed dock. Root, leaves, seed.

Iris *palustris lutea.* Acorus adulterinus. C. B. pin. 34. Water-flag. Root.

Nymphæa *lutea major.* C. B. pin. 193. Yellow water-lily. Root.

——— *alba major.* C. B. pin. 193. White water-lily. Root.

No. 84.

Process for Dyeing Nankeen Colour. By Mr. Richard Brewer.*

MIX as much sheep's dung in clear water as will make it appear of the colour of grass, and dissolve in clear water one pound of best white soap for every ten pounds of cotton-yarn, or in that proportion for a greater or lesser quantity.

Observe:—The tubs, boards, and poles, that are used in the following operations must be made of deal; the boiling-pan of either iron or copper.

First Operation.

Pour the soap liquor prepared as above into the boiling-pan; strain the dung liquor through a sieve; add as much thereof to the soap liquor in the pan as will be sufficient to boil the yarn, intended to be dyed, for five hours. When the liquors are well mixed in the pan, enter the

* Tilloch, vol. 17, p. 149. From the *Transactions of the Dublin Society*, vol. 1; part 1.

yarn, light the fire under the pan, and bring the liquor to boil in about two hours, observing to increase the heat regularly during that period. Continue it boiling for three hours, then take the yarn out of the pan, wash it, wring it, and hang it in a shed on poles to dry. When dry, take it into a stove or other room where there is a fire; let it hang there until it be thoroughly dry.

N. B. The cotton yarn, when in the shed, should not be exposed either to the rain or sun: if it is, it will be unequally coloured when dyed.

Second Operation.

In this operation use only one half of the soap that was used in the last, and as much dung liquor (strained as before directed) as will be sufficient to cover the cotton yarn, when in the pan, about two inches. When these liquors are well mixed in the pan, enter the yarn, light the fire, and bring the liquor to boil in about one hour; then take the yarn out, wring it without washing, and hang it to dry as in the former operation.

Third Operation.

This operation the same as the second in every respect.

Fourth Operation.

For every ten pounds of yarn make a clear ley from half a pound of pot or pearl ashes. Pour the ley into the boiling-pan, and add as much clear water as will be sufficient to boil the yarn for two hours; then enter the yarn, light the fire, and bring it to boil in about an hour. Continue it boiling about an hour, then take the yarn out, wash it very well in clear water, wring it, and hang it to dry as in former operations.

Process for Dyeing Nankeen Colour.

N. B. This operation is to cleanse the yarn from any oleaginous matter that may remain in it after boiling in the soap and dung liquors.

Fifth Operation.

To every gallon of iron liquor* add half a pound of ruddle or red chalk (the last the best) well pulverized.

Mix them well together, and let the liquor stand four hours, in order that the heavy particles may subside; then pour the clear liquor into the boiling pan, and bring it to such a degree of heat as a person can well bear his hand in it; divide the yarn into small parcels, about five hanks in each; soak each parcel or handful very well in the above liquor, wring it, and lay it down on a clean deal board. When all the yarn is handed through the liquor, the last handful must be taken up and soaked in the liquor a second time, and every other handful in succession till the whole is gone through; then lay the yarn down in a tub, wherein there must be put a sufficient quantity of ley made from pot or pearl ashes, as will cover it about six inches. Let it lie in this state about two hours, then hand it over in the ley, wring it, and lay it down on a clear board. If it does not appear sufficiently deep in colour, this operation must be repeated till it has acquired a sufficient degree of darkness of colour: this done, it must be hung to dry as in former operations.

N. B. Any degree of red or yellow hue may be given to the yarn by increasing or diminishing the quantity of ruddle or red chalk.

* Iron liquor is what the linen printers use.

Sixth Operation.

For every ten pounds of yarn make a ley from half a pound of pot or pearl ashes; pour the clear ley into the boiling-pan; add a sufficient quantity of water thereto that will cover the yarn about four inches; light the fire, and enter the yarn, when the liquor is a little warm; observe to keep it constantly under the liquor for two hours; increase the heat regularly till it come to a scald; then take the yarn out, wash it, and hang it to dry as in former operations.

Seventh Operation.

Make a sour liquor of oil of vitriol and water; the degree of acidity may be a little less than the juice of lemons; lay the yarn in it for about an hour, then take it out, wash it very well and wring it; give it a second washing and wringing, and lay it on a board.

N. B. This operation is to dissolve the metallic particles, and remove the ferruginous matter that remains on the surface of the thread after the fifth operation.

Eighth Operation.

For every ten pounds of yarn dissolve one pound of best white soap in clear water, and add as much water to this liquor in your boiling-pan as will be sufficient to boil the yarn for two hours. When these liquors are well mixed light the fire, enter the yarn, and bring the liquor to boil in about an hour. Continue it boiling slowly an hour; take it out, wash it in clear water very well, and hang it to dry as in former operations: when dry it is ready for the weaver.

N. B. It appears to me, from experiments that I have made, that less than four operations in the preparation of the yarn will not be sufficient to cleanse the pores

of the fibres of the cotton, and render the colour permanent.

No. 85.

Observations on the Employment of Platina in Porcelain Painting. By Professor Klaproth.*

IN the course of half a century since platina was introduced and known in Europe, the experiments made with it by various eminent chemists seem to have exhausted every thing that relates to the physical and chemical properties of this remarkable metal. The imperfect information, however, which relates to its mineralogical and natural history seems to require further investigation, though it must at the same time be acknowledged that our information in this respect appears to be worthy of confidence, as the Spanish government has entrusted the inspection and management of its mines in South America to men who to a knowledge of mineralogy and mining unite great zeal for the improvement of these sciences.

The real origin of platina is in all probability to be ascribed to revolutions which have taken place in the Cordilleras by volcanoes, earthquakes, and inundations; and it is not improbable that these mountains still contain in their interior parts entire veins of platina, the discovery of which is perhaps reserved for future times.

At present, Peru is the only known country where platina is found, and particularly the district of Choco, where it is collected in the valleys between the moun-

* Tilloch, vol. 17, p. 135. From Scherer's *Allgemeines Journal der Chemie*, no. 52, 1802.

tains and rivers along with the gold in small laminæ, or it is obtained by washing the earth.* When the largest grains of gold have been picked from the mixed mass of gold and platina, the remaining gold is extracted by amalgamation; by means of which operation the platina is left behind in the form of flat plates or scales.

The deceptions formerly practised by mixing gold with platina have induced the Spanish government to prevent the exportation of it, and to give orders to all their servants in that country to keep the platina by them, and to wash it in water from time to time. But as means have been found to detect easily and in a certain manner the adulteration of gold with platina, and also to employ it for valuable purposes, it is to be hoped that the Spanish government will not persist in causing a prohibition so injurious to the arts and to its own finances to be executed with the former severity.

My object at present is not to enlarge on the chemical and physical properties of platina, but only to offer a few observations on the uses in the arts to which it has hitherto been applied; and then to give an account of the result of an experiment which I made in regard to a new application of this metal to objects of manufacture.

The apparent infusibility of platina by itself, formerly considered as an insuperable obstacle, was sufficient to prevent the employment of it except in combination with other metals, as experience showed that it was capable of uniting with the greater part of them by fusion. Of such mixtures, that arising from a combination of brass and platina was found to be exceedingly proper for the specula of reflecting telescopes, as this alloy was

* Platina is found in Spain, and also in St. Domingo.

susceptible of a beautiful polish not subject to be injured by the prejudicial influence of the atmosphere and of moisture. At first, however, the employment of platina was not extended further until the experiments made known by Morveau, Sage, and other chemists, and afterwards prosecuted on a larger scale by count Von Sickingen, formed as it were an epoch in the history of this metal, and showed in what manner platina might be freed from its foreign particles, be welded, hammered, and drawn out into wire, so as to be applicable to a variety of purposes.

It was, however, not yet possible to employ it in cases which required an actual fusion for the purpose of casting it; because this metal, in its purified state, was always by itself infusible in a common furnace. It was therefore a discovery of great importance to find that platina may be rendered fusible by arsenic; and that when mixed with this substance it may be cast in moulds, while the volatile metal employed as a flux may be again driven off by heat, so that the cast platina may then be hammered like any other metal. By employing this method, first made known by my worthy colleague M. Achard, vessels and articles of various kinds are made of platina, and particularly at Paris.

Bergman, however, had shown that platina which could be reduced to a state of fusion only by employing a large burning mirror, might be fused also by means of oxygen gas. In this manner M. Pelletier, by means of phosphoric glass, made from bones, combined with charcoal powder, brought large masses of platina to a state of complete fusion.

How far platina might be employed in porcelain painting has never yet, as far as I know, been examined: I therefore thought it of considerable importance to make some experiments on this subject, which did not deceive

my expectation; but, on the contrary, convinced me that this object, in the hands of an ingenious artist, may be brought to perfection.

Gold and silver have hitherto been the only metals susceptible of being employed in their metallic form in painting and ornamenting porcelain, glass, and enamel. Gold answers this purpose so completely, that nothing further can be wished for on this head; whereas silver does not answer so well. As it possesses less density and is more porous than gold, it does not cover the ground so completely when applied to porcelain in thin leaves. The second cause of the inferiority of silver when employed in painting on porcelain arises from its nature, in consequence of which, when exposed to sulphureous and other phlogistic vapours, it becomes tarnished, loses its metallic splendour, and at length grows black. This inconvenience renders silver unfit for being employed in fine porcelain painting, and confines the application of metallic substances in this manner to gold alone.

Platina, in this respect, may be classed next to gold; and by its white colour may supply the place of silver without possessing any of its faults. It is not only capable, on account of its density and weight, in which it exceeds gold, of covering the ground completely, without leaving any perceptible interstices, as silver does; but it withstands like gold all the variations of the atmosphere, as well as sulphureous and other vapours.

The process which I employ in the application of platina to painting on porcelain is simple and easy: it is as follows:—I dissolve crude platina in aqua regia, and precipitate it by a saturated solution of sal ammoniac in water. The red crystalline precipitate thence produced is dried, and being reduced to a very fine powder

is slowly brought to a red heat in a glass retort. As the volatile neutral salt, combined with the platina in this precipitate, becomes sublimated, the metallic part remains behind in the form of a gray soft powder. This powder is then subjected to the same process as gold; that is to say, it is mixed with a small quantity of the same flux as that used for gold, and being ground with oil of spike is applied with a brush to the porcelain; after which it is burnt in under the muffle of an enameller's furnace, and then polished with a burnishing tool.

The colour of platina burnt into porcelain in this manner is a silver white, inclining a little to a steel gray. If the platina be mixed in different proportions with gold, different shades of colour may be obtained; the gradations of which may be numbered from the white colour of unmixed platina to the yellow colour of gold. Platina is capable of receiving a considerable addition of gold before the transition from the white colour to yellow is perceptible. Thus, for example, in a mixture of four parts of gold and one of platina, no signs of the gold were to be observed, and the white colour could scarcely be distinguished from that of unmixed platina: it was only when eight parts of gold to one of platina were employed that the gold colour assumed the superiority.

I tried, in the like manner, different mixtures of platina and silver; but the colour produced was dull, and did not seem proper for painting on porcelain.

Besides this method of burning-in platina in substance on porcelain, it may be employed also in its dissolved state; in which case it gives a different result both in its colour and splendour. The solution of it in aqua regia is evaporated, and the thickened residuum is then applied several times in succession to

the porcelain. The metallic matter thus penetrates into the substance of the porcelain itself, and forms a metallic mirror of the colour and splendour of polished steel.*

No. 86.

Extract of a Memoir read in the French National Institute, on the Strength of the Flax of New Zealand, compared with that of the Filaments of the Aloe, of Hemp, Flax, and Silk. By C. LABILLARDIERE.†

THE flax of New Zealand, which, as is well known, is obtained from a plant of the family of the asphodela, called *Phormium tenax*, holds the first rank among the vegetable fibres, yet known, proper for the making of ropes. This fact was first made known by the celebrated Captain Cook and his illustrious fellow-navigator Sir Joseph Banks. It was afterwards confirmed by Dr. Forster, who gave a good description of the plant, which he found growing in full vigour during various excursions in New Zealand, at several parts of which he touched when he accompanied Captain Cook on his second voyage round the world. A good figure of the plant may be seen in the first volume of the account of that voyage, and also in Miller's *Icones Plantarum*. Dr. Forster has described all the parts of fructification, and illustrated them with figures, in his work on the new genera of plants discovered in the South Seas.

* At the time this paper was read in the Royal Academy of Sciences the author exhibited several patterns of porcelain ornamented in this manner, which had been made in the royal observatory.

† Tilloch, vol. 17, p. 341.

No person, however, has ever yet attempted to ascertain how far the fibres of the *Phormium tenax* are superior in strength to those of hemp. This is the object of the present memoir, in which I shall compare their strength with that of the filaments of the aloe, of flax, and of silk. It is of the more importance to examine the strength of the flax of New Zealand, as compared with that of hemp in particular, because it might be substituted for the latter with great advantage in the navy, whereas the other substances are too scarce and too dear, or much inferior in quality.

The flax of New Zealand, which I submitted to examination in order to ascertain its strength, was given to me in exchange for toys by some of the inhabitants of that extensive country, with whom we had an intercourse, towards its northern point, during the voyage undertaken in search of Perouse; Ventose 22d, 1st year of the republic. The plant which produces it is of great use to these savages; and when they approached us, the first articles they exhibited were large handfuls of its leaves prepared for various purposes. Even when at a considerable distance from us they waved them with a sort of enthusiasm, as if desirous to make known to us their value, and we soon found that we had properly understood this kind of language, for they set a very high price on them when they got on board our vessel.

For my experiments I preferred these filaments to those produced from the leaves of the same plant raised in green-houses, where the fibres certainly do not acquire so much strength as in the open air; besides, the season proper for collecting leaves capable of giving the strongest fibres can be known only by experience.

The apparatus I employed for ascertaining the strength of the different fibres which I subjected to trial consisted of two pieces of wood, ten inches in height, fixed on a plank in a vertical direction, at the distance of six centimetres, or 2.598 inches from each other; they were slightly rounded at the upper extremity, and on the exterior part of each was fixed a small iron cylinder, about a millimetre in diameter. To these two small cylinders I affixed the filaments the strength of which I intended to try. They rested on each side on the rounded extremities of the pieces of wood already mentioned. I took the precaution to employ fibres of the same diameter, that is one-tenth of a millimetre or 0·0443 of a line, which I verified by means of a microscope and a good micrometer, taking care to twist equally the part of the filament which I examined, having chosen it as far as possible of the same dimensions throughout its whole length. I tried the strength of it from every eight centimetres to eight centimetres, or every two inches 11.464 lines, which was the distance between the pieces of wood, and I suspended from about the middle of it, by means of a wire hook well covered with hemp, a weight which I increased until the filament was broken.

I took care that it should not be twisted, in order that I might ascertain its whole strength, for without this precaution it would have broken, as is well known, much sooner. Besides, for many reasons which it would be superfluous to mention here, I should have obtained results much less certain; and it is needless to observe that, in such cases, a rigorous determination cannot be obtained, but merely an approximation.

After having tried the strength of twelve lengths of hemp, as above described, and having divided the sum by that number, to ascertain the mean strength of each, I found that it was equal to sixteen and one-third, while

that of the fibres of the *Phormium tenax*, tried in the same state, was twenty-three and five-elevenths. The filaments of the aloe gave only seven, flax eleven and three-fourths, and silk thirty-four; or, in other words, the fibres of hemp broke only with a weight of 400.3917 grammes, that of the flax of New Zealand by 590.5034 grammes, flax by 295.8228 grammes, and silk by 855.9978 grammes.

The hemp and flax which I employed for these experiments were the first fibres of the best kind produced in the department of L'Orne. I extracted, by maceration and slight friction to detach the parenchyme, the fibres of the aloe from a leaf of the *Agave fœtida*, Linn. or the *Furcræa gigantea* Vent. which was given to me by my colleague C. Thouin.

I must here observe, that at first I took the filaments of a diameter much smaller, one twentieth of a millimetre, or 0.0221 of a line, and even less; but I soon observed that it was difficult to obtain them of that tenuity without a great many inequalities and other defects, which prevented the exactness of the results; besides, the more delicate they were, the more difficult it was to ascertain their diameter. I paid attention, therefore, to those only the diameter of which was one-tenth of a millimetre.

It may, therefore, be readily conceived what advantage it would be to the navy to have ropes, the strength of which, were it confined merely to this proportion, would be almost one-half greater than that of hemp ropes. But I have no hesitation to assert that it will far exceed it; for the fibres of the flax of New Zealand, according to a series of comparative experiments which I made on purpose to determine the tension of which they are susceptible before they break, are more tensible by one-half than those of hemp; and the principal cause of the dimi-

nution of the strength of a rope, in proportion to its being more twisted, arises in particular from the fibres of which it is composed experiencing different degrees of tension, the strength and inequality of which are increased by torsion. But it is evident that the more the fibres which enter into a rope are susceptible of tension, the less is the difference in the distribution of their strength, whence it results that the most tensible fibres, *cæteris paribus*, will always make the best ropes.

It has been observed that certain kinds of hemp, with stiff, but very strong fibres, are often capable of less resistance, when employed to make ropes, than other kinds, the fibres of which are weaker, but softer and more flexible. It is besides known, that stiff fibres break by a weak degree of torsion, which is resisted by those that have more flexibility.

To ascertain the tensibility of the fibres of the flax of New Zealand, I took six of one-tenth of a millimetre, or 0.0443 line in diameter, and suspended to lengths of fourteen centimetres, or five inches 2.062 lines, a weight which I gradually increased, examining by what quantity they were extended before they broke. The sum of these quantities, divided by the number of the filaments subjected to trial, gave for quotient the mean term of the tensibility of each. Having subjected to the same trial the filaments of the aloe, of hemp, of flax, and of silk, the results which I obtained were: for the flax 1.1279 millimetres; for the hemp 2.2558; for the flax of New Zealand 3.3837; for the aloe 5.6395; and for the silk 11.2790: so that the tensibility of flax being equal to half that of hemp will be expressed by 1; that of the *Phormium tenax* by one and an half; that of the filaments of the aloe by two and a half; and that of silk by five. It is thence seen what prodigious power of resistance is

exhibited by a few threads of silk, carefully spun, as their very great tensibility causes them all to make an effort nearly equal before they yield to the effort made to break them.

It may not be improper here to remark, that the Chinese, who make great use of silk strings for their musical instruments, have no doubt found that twisting them for that purpose hurts their strength, and also the justness of the sound, for they are manufactured without twisting; the threads of which they are composed being merely united by means of an elastic resin: on this account they are, on the first view, taken for catgut. I have no doubt that if our artists would attempt this new manufacture, their labours would be attended with success, especially as they employ with great dexterity various kinds of elastic resin; but that extracted from the *Vahe* of Madagascar, (*Vahea elastica,*) would be preferable to caoutchouc, which comes from Guyana, because the latter has a very dark tint, while the other inclines very much to a white colour. It readily dissolves, as is well known, in ether. Besides gum elastic extracted from several other vegetables might also be employed for the same purpose.

The *Phormium tenax* is far from being the only plant of the division of the monocotyledons, capable of furnishing filaments proper for the uses of rope-making; for besides some gramineous plants, most of the palms, and all the species of the Agave, &c. there are many others of this great division which have not yet been employed, and which might be turned to advantage, particularly several kinds of iris, the leaves of which possess very great strength.

I must here observe, that in most plants of the division of the monocotyledons, the leaves produce the filaments proper for the purposes of rope-making; and the

disposition of their fibres, which is nearly parallel throughout the whole length of the leaves, will call to the remembrance of botanists the excellent memoir of our colleague Desfontaines, on the organization of the monocotyledon plants. On the other hand, in the division of the dicotyledons, the filaments employed for ropes is obtained from the bark; and it is well known, that among the great number of sections which these vegetables contain, they are found chiefly in those of the *Thymeli*, *Urticæ*, *Malvaceæ*, *Tiliæ*, and the *Amentaceæ*. The bark of a shrub of the first section (of a new kind of *Pimelea*) produces filaments which I have seen the inhabitants of Cape Van Diemen employ for the purpose of making ropes. These savages have so little industry, that they use them without the least preparation. They even take no advantage of a very excellent kind of flax which grows spontaneously on their coasts. The crude bark of the *Pimelea* abovementioned formed the handles of some baskets made of reeds, which the women at the hours of repast filled with shell-fish, diving in the sea to considerable depths, at the risk of being devoured by sharks, or of being detained at the bottom of the water by marine plants, some of which, and particularly the *Ficus pyriferus*, are several hundreds of feet in length.

They employed this bark also for fastening round their bodies the skin of the kangaroo, the only clothing worn by the best dressed of these savages; for several of them were entirely naked, though exposed to severe cold in the latitude of forty-four degrees south, and by a very strange kind of whim this vestment served only to cover the shoulders.

The *Phormium tenax* will succeed perfectly in France, for it is found in New Zealand from latitude thirty-four degrees to latitude forty-seven degrees south, and is ex-

posed there to very severe frosts in the most southern part of that very large country. Moist places are better suited to it than dry, and the same may be said of most of the other *Lilacæi*. It would thrive well in many of the marshy districts, which at present are considered as useless; besides, it is a lively plant, and will require very little care. It may readily be conceived what advantages must result from the culture of this valuable plant, and particularly to the navy, as it will lighten in a very considerable degree the lading of our vessels, for the weight of the rigging in a 74-gun ship is estimated at 1714.005 myriagrammes, or sixty-eight thousand pounds. The use of the flax of New Holland would lessen this weight more than one-half; and also that of the other ropes, which are above the line of flotation; and therefore the vessel would be capable of taking in a much greater quantity of provisions. Besides, it is well known that the less the diameter of the ropes above the line of flotation, the less will be the lee-way; and, therefore, these new ropes will contribute to accelerate the progress of ships of war, which will still be increased by the lightening they will experience when loaded with a less weight than usual. These ropes being smaller and lighter than those made with hemp, fewer hands will be required to manage them; so that, if introduced, ships will need fewer men than those rigged with hemp.

It is evident also that fibres so strong and so pliable will be proper for the fabrication of different kinds of cloth, and may be substituted with advantage in our manufactories for hemp and even flax. They will no doubt retain in the loom that superiority which they have in strength over hemp. Their whiteness and silky appearance give reason to hope that cloth made

of them will exceed in beauty that manufactured from flax.

All the dresses which we purchased from the savages of New Zealand were made from the fibres of their flax. To cords of the same substance they had attached different ornaments, among which were pieces of human bones, and which were suspended on their breast as a kind of trophy. They seemed to attach great value to them, and were very unwilling to part with them.

Their fishing-lines were formed of two filaments twisted together; but their nets were made from the leaves of a plant separated into filaments, without any other preparation. As their nets are of prodigious extent, for the purpose of fishing at a great distance from the coast, these savages do not make them of ropes, because this labour would require much time, and they besides find that their flax employed in this manner is sufficient.

All the piroguas which approached us had on board men armed for the most part with stones, some of them of granite, and others of serpentine, which they had attached to their wrists with cords of the *Phormium tenax;* but I must observe that these were only defensive weapons, for they did every thing in their power to engage our confidence, and soon consented to exchange these weapons for our hatchets, and for other instruments of iron, on which these warlike people set great value.

It follows from the experiments, the results of which I have here given, 1st, that the strength of the fibres of the aloe being equal to seven; that of flax is represented by eleven and three-fourths; that of hemp by sixteen and one-third; that of the flax of New Zealand by twenty-three and five-elevenths; and that of silk by thirty-four.

But the quantity they stretch before they break is in another proportion; for that of the filaments of the aloe being equal to two and a half; that of flax is only one-half; that of hemp one; that of the flax of New Zealand one and a half; and that of silk five. 2d, That great advantages will result from the cultivation of the New Zealand flax in France, where it will thrive exceedingly well.

No. 87.

Description of a Method of preventing Injury to the Health of the Workmen employed in preparing White Lead. By Mr. Archer Ward.

(With an engraving.)

IN order to explain, as well as I can, the advantage that will accrue to the workmen by adopting my invention, in preference to the common mode of preparing white lead, I will first state what the common mode is. When blue lead is in part corroded in the stacks, by an acid raised by a considerable degree of heat, brought on by horse-litter, the corroded and uncorroded lead are taken from the stacks to a room called the engine-loft, where a pair of iron rollers is fixed with a screen under them. The lead in this state is passed through the rollers and screen; from the motion of these rollers and screen, by which the white lead is separated from the uncorroded or blue lead, together with the moving the lead in order to its being passed through them, a very considerable quantity of fine dusty white lead is raised, which

* Repertory, vol. 5. p. 249. From the *Transactions of the Society for the Encouragement of Arts, &c.*—The gold medal of the Society was voted to Mr. Ward for this invention.

almost covers the workmen thus employed, and is very pernicious to them. And not only in this part of the process are they liable to be thus injured, but they are again exposed to the dusty lead, by removing the blue lead from the screen-house to the furnace, as there still remains a quantity of the fine particles of white lead, which of course rises in removing it; and also, in removing the white lead from under the screen to the grinding-tub, a quantity of the dust arises, which is very detrimental to the people so employed.

My invention removes all these difficulties respecting the dry dusty white lead, so very injurious to the health of the working people; and consists of a vessel, as shown in plate 13, fig. 1, twelve feet long, six feet wide, and three feet ten inches deep. In this vessel is fixed a pair of brass rollers in a frame, one roller above the other. The centre of the rollers is about ten inches below the top of the vessel; and, one inch lower, is a covering of oak boards or riddles, an inch thick, fixed in the inside of the vessel, in a groove, so as to be taken out occasionally: these boards are bored, with a centre-bit, as full of holes as may be, without danger of breaking into each other; the size of these holes is, in the machine at large, about five-eighths of an inch diameter. This being done, the vessel is filled with water, about three inches above the oak boards or riddles; the lower brass roller is now under water, and about half of the upper roller is under water also. Thus the lead coming from the stacks is put through the brass rollers in water, and, by raking the lead with a copper rake over the oak boards or riddles, the white lead passes through the riddles, and the blue lead remains above; which, being taken out, is thrown upon an inclined plane of strong laths to drain, where it remains about twelve hours, when the blue lead is ready for the furnace to be remelted; by this means no

dusty white lead can rise in any part to the work-people. No such plan as this (although long desired) has, to my knowledge, been put in execution, so as to answer all the purposes above stated. It may be asked, why the lead in the common mode is not made wet before it is passed through the rollers and screen. Should this be done, the lead would be a paste on the rollers and screen, and the white lead prevented separating from the blue lead, which is absolutely necessary in the preparation of white lead.

Reference to the Engraving, Plate 13.

Fig. 1, A, an inclined plane of wood, on which the white and blue lead is placed immediately from the stacks, and thus introduced between the brass rollers BB.

CC, the vessel containing water.

DDD, the pierced oak boards or riddles, which, by being made to slide in grooves in the sides of the vessel CC, may occasionally be taken out by removing the wooden bar *ee*.

E, a handle or winch, which, in the machine at large, may be a wheel communicating to mill-work, and thus turn the rollers BB.

F, a pinion, fixed on the gudgeon of the upper roller, and communicating with a similar pinion on the arbor of the lower roller, keeping both of them in motion by the turn of the handle. As it is necessary that the upper roller should be at liberty to rise or fall, in order to give a due degree of pressure to the lead in passing between the rollers, two weights GG, with proper stems to them, (as shown more at large in fig. 2,) are placed over the gudgeons of the upper roller, thereby keeping a due degree of pressure; and, if any piece of the lead should be

thicker than usual, admitting the roller to give way to it, and thereby preventing any injury to the machinery.

H, a notch in one side of the wooden vessel, serving to regulate the depth of the water on the riddles DDD.

The foregoing description is accompanied by two certificates; one from Mr. Samuel Walker Parker, stating that many tons of white lead have been made, in the manner above described, at the manufactory at Islington belonging to Walker, Ward, and Co. and that, since Mr. Ward's plan was adopted, no other method has been used. The other certificate is from Mr. H. Browne, of Irongate, Derby; who says that he thinks the foregoing invention a very valuable improvement in preparing white lead, and that the quality of the lead is not in the least injured by it.

No. 88.

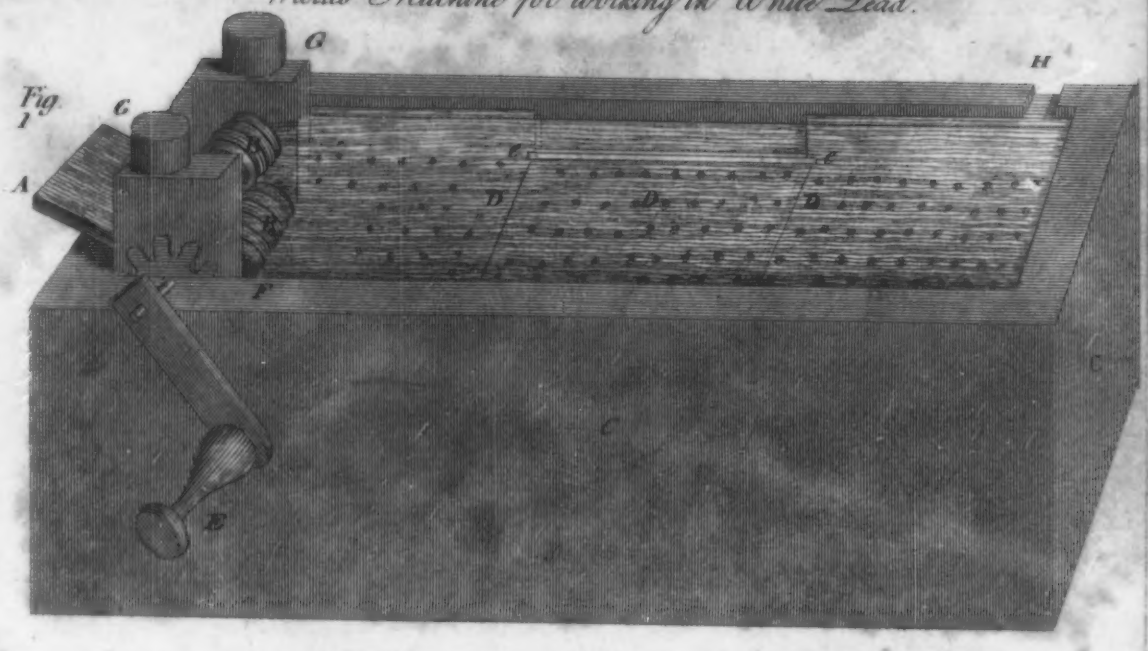
Description of an improved Mill for levigating Painters' Colours. By Mr. James Rawlinson.*

(With an engraving.)

THE hitherto very unmechanical, inconvenient, and highly injurious method of grinding poisonous and noxious colours, led me first to imagine a better might easily be contrived for that purpose. It must be obvious to every person, that the method hitherto adopted of grinding colours on an horizontal marble slab, with a small pebble muller, requires the body of the person who grinds to bend over that slab, and consequently his

* Nicholson, vol. 11, p. 119. From the *Memoirs of the Society of Arts* for 1804.—The Society awarded him the silver medal.

Wards Machine for working in White Lead.



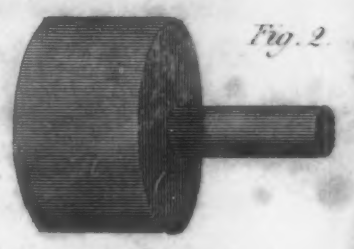


Fig. 2

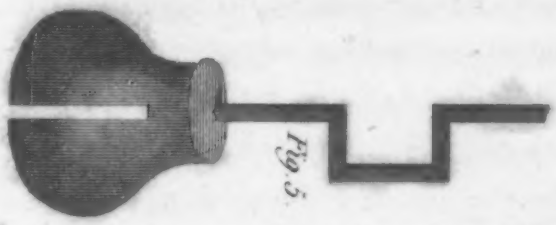


Fig. 5

Improved Indigo Mill.

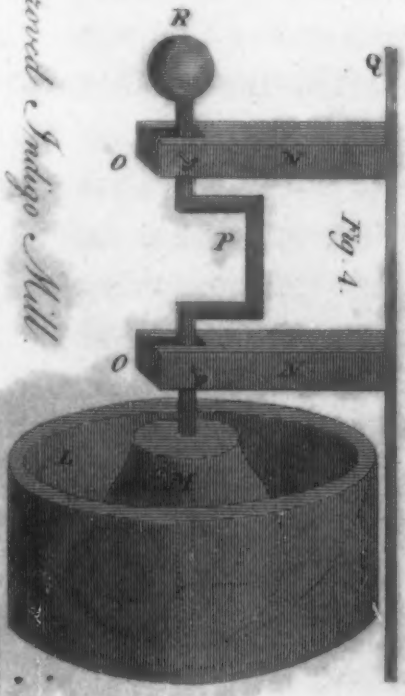


Fig. 4

Rawlinsons Colour Mill

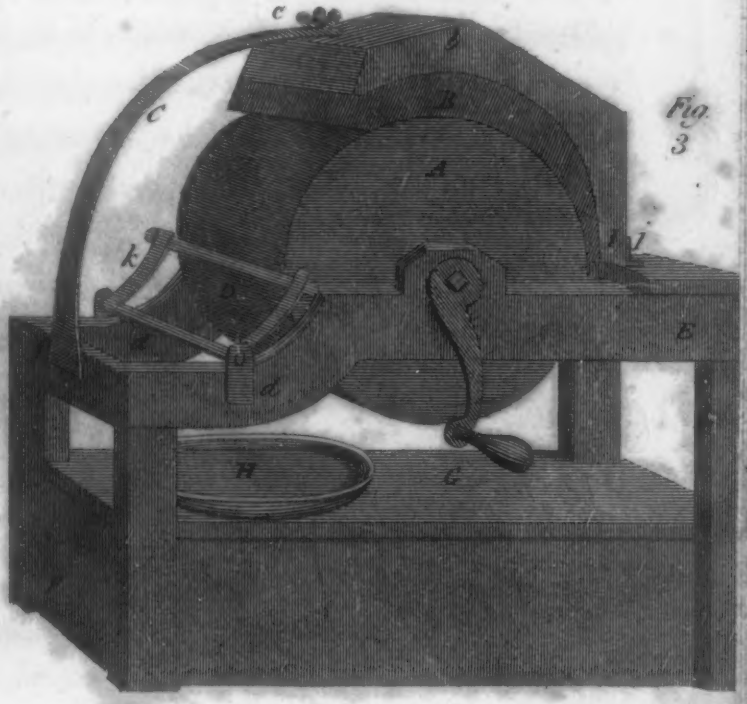


Fig. 3

Emporium of Arts & Sciences Vol. 2. pl. 13.

Tiebout.

head; which causes him constantly to inhale the noxious and poisonous volatile parts of the paint, which is not unfrequently ground with oil saturated with litharge of lead; and if we may judge from the very unhealthy appearance of these men, accustomed to much colour-grinding, it should seem the bad effects of this employment require a speedy remedy.

The machine, of which I now send the Society a model, has not only the advantage of being an effectual remedy of this extensive and severe evil to recommend it, but it grinds the colour much easier, much finer, and much quicker, than any method hitherto adopted. Having occasion for a considerable quantity of colour-grinding in the profession in which I am engaged, and that in the finest state possible, and having made use of this machine for several years, and being more and more convinced of its utility, I thought it my duty to present it to the Society of Arts, hoping that it might not be altogether unworthy of their attention. The roller of the machine that I use is sixteen inches and a half in diameter, and four inches and a half in breadth. The concave muller that it works against covers one third of that roller: it is therefore evident, that with this machine I have seventy-two square inches of the concave marble muller in constant work on the paint, and that I can bring the paint much oftener under this muller in a given space of time, than I could by the usual method with the pebble muller, which is seldom more than four inches in diameter, and consequently has scarcely sixteen square inches at work on the paint, when my concave muller has seventy-two. I do not mean to say that a roller, the size of that which I now use, is the largest which might be employed; for truly I believe that a roller two feet in diameter, with a concave muller in proportion, would not be

hard work for a man; and then the advantage to the public would be still farther increased.

This machine will be found equally useful for the colours ground in water, as for those ground in oils; and I doubt not but the great importance of this simple machine will be very soon generally experienced in all manufactories where colours are used. The labour necessary with this machine, in grinding colours exceedingly fine, is very easy. It is useless to enter into any minute description in this place, as a bare inspection of the machine must sufficiently explain itself.

To the colourman it would evidently be an essential saving of labour, and consequently of expense, which will probably have some weight as a recommendation; and the advantages to the colour-grinder have been already stated.

Reference to the Engraving. Plate 13, *Fig.* 3.

A is a roller or cylinder made of any kind of marble; black marble is esteemed the best, because it is the hardest, and takes the best polish. B is a concave muller covering one-third of the roller, of the same kind of marble, and fixed in a wooden frame *b*, which is hung to the frame E at *ii*. C is a strong piece of iron, sbout an inch broad, to keep the muller steady, and is fixed to the frame with a joint at *f*. The small binding-screw, with the fly-nut, that passes through the centre of the iron plate at *c*, is for the purpose of laying more pressure on the muller, if required, as well as to keep it steady. D is a taker-off, made of a clock-spring about half an inch broad, and fixed in the manner of a frame-saw, in an iron frame *k*, in an inclined position to the roller, and turning on pivots at *dd*. G is a slide-board to draw out occasionally, to clean, &c. if any particles of paint should fall from the roller, and which also forms itself for the plate

H, to catch the colour on as it falls from the taker-off. F is a drawer, for the purpose of containing curriers' shavings, which are the best things for cleaning paint-mills.—E is the frame.

Previous to the colour being applied to the mill, I should recommend it to be finely pulverized in a mortar, covered in the manner of the chemists when they levigate poisonous drugs.* This process of dry-grinding is equally necessary for the marble slab now in use; after which it should be mixed with oil or water, and with a spatula or pallet-knife put on the roller, near to the top of the concave muller, and the roller turned round, which takes the colour under the muller without any difficulty, and very few turns of the roller spread it equally over its surface. When it is perceived sufficiently fine for the purpose required, it is very easily taken off by means of the taker-off described, which must be held against the roller, and the roller turned the reverse way, which cleans it very quick and very completely; and the muller will only require to be cleaned when you desist or change the colour. It is then turned back, being hung on pivots to the frame at *i i*, and cleaned with a pallet-knife or spatula very conveniently. Afterwards, a handful of curriers' shavings held on the roller, with two or three revolutions cleans it effectually; and there is less waste with this machine than with any marble slab.

* Or rather in an improved mill, used at Manchester by Mr. Charles Taylor, for grinding indigo in a dry state, of which I have annexed a drawing, and reference, to render the whole business of colour-grinding complete.—*Note of the Author.*

This is the same apparatus as was used under the name of *a philosophical mill*, in the laboratory at Gottorp, about the beginning of the last century. See the memoir of Dr. Joel Langelot, with an engraving, in Lowthorp's Abridgment of the Philosophical Transactions, vol. 3, p. 318.—NICHOLSON.

As to the quantity ground at once on this mill, it must be regulated by the state of fineness to which it is required to be ground. If it is wanted to be very fine, a smaller quantity must be put on the roller at a time; and as to time requisite for grinding a given quantity of colour, this will also depend on the state of fineness to which it is ground. I have observed that my colour-grinder has ground the quantity of colour which used to serve him per day, with this machine, in three hours, and, as he said, with ease. The colour also was much more to my satisfaction than in the former way, and attended with less waste.

I have mentioned the pulverizing the colours in a covered mortar, which would prevent waste, and prevent the dust and finest parts of noxious colours from being injurious to the grinder. In some manufactories, where large quantities of colours, prepared from lead, copper, and arsenic, are used, this precaution is particularly necessary. I do not mean to say that my machine is intended to supersede the paint-mill now in use for coarse common colours. It is intended for no such purpose; but to supersede the use of the very awkward and unmechanical marble slab now in use, and on which all the colours for china manufactories, coach-painters, japanners, and colour-manufacturers for artists, &c. are now ground.

Several of the colour-manufacturers have expressed to me their great want of such a machine; and that I had no desire of troubling the public with a machine that would not answer, is evident, from my having used it several years before I presumed to recommend it to their attention. Being therefore now completely convinced of its utility, and hoping that it might relieve a number of my fellow-creatures from a dangerous employment, I have ventured to commit it to the protection of the Society of

Arts; hoping, through their means, to see its ultimate success. And, further to give the Society the most complete assurance in my power, I have annexed the opinion of a very ingenious and mechanical friend of mine who has frequently seen it work. If any other questions should occur to the Committee, that may be in my power to explain, I shall gladly do so. I am, &c.

JAMES RAWLINSON.

Derby, February 6, 1806.

To CHARLES TAYLOR, Esquire.

P. S. When the colour is ground, I recommend the following mode of tying it up in bladders, in preference to the usual method. Instead of drawing the neck of the bladder close, in the act of tying it, insert a slender cylindrical stick, and bind the bladder close around it. This, when dry, will form a tube or pipe, through which, when the stick is withdrawn, the colour may be squeezed as wanted, and the neck again closed by replacing the stick. This is not only a neater and much more cleanly mode than the usual one of perforating the bladder; and stopping the hole with a nail, or more commonly leaving it open, to the prejudice of the colour; but the bladder, being uninjured, may be used repeatedly for fresh quantities of colour.

N. B. The barrel of a quill may be tied, in place of the stick, into the neck of the bladder, with its closed end outwards, which will keep the colour secure in travelling, and when used, the end of the quill being cut off, it may afterwards be closed by a stick.*

* A certificate from Mr. Thomas Swanwick, of Derby, and also from Mr. John Middleton, of St. Martin's Lane, confirming the above statement, accompanied these papers.

Reference to the Engraving (Plate 13) of an improved Mill for grinding Indigo, or other dry Colours.

FIG. 4. L represents a mortar made of marble or hard stone; one made in the common way will answer. M, a muller or grinder, nearly in the form of a pear, in the upper part of which an iron axis is firmly fixed, which axis, at the parts NN, turns in grooves or slits, cut in two pieces of oak projecting horizontally from a wall, and when the axis is at work, are secured in the grooves by iron pins, OO. P, the handle, which forms a part of the axis, and by which the grinder is worked. Q, the wall in which the oak pieces NN are fixed. R, a weight which may occasionally be added, if more power is wanted.

Fig. 5, shows the muller or grinder, with its axis separate from the other machinery; its bottom should be made to fit the mortar. S is a groove cut through the stone.

On grinding indigo, or such substance, in a dry state, in this mill, the muller being placed in the mortar, and secured in the oak pieces by the pins, the indigo to be ground is thrown above the muller into the mortar; on turning the handle of the axis, the indigo in lumps falls into the groove cut through the muller, and is from thence drawn under the action of the muller, and propelled to its outer edge within the mortar, from whence the coarser particles again fall into the groove of the muller, and are again ground under it; which operation is continued, till the whole of it is ground to an impalpable powder; the muller is then easily removed, and the colour taken out.

A wood cover, in two halves, with a hole for the axis, is usually placed upon the mortar, during the operation,

to prevent any loss to the colour, or bad effect to the operator.

No. 89.

The Process for refining Lead, as practised in England. In a Letter from Mr. John Sadler.*

(With two engravings.)

MY dear Sir—Citizen Duhamel, in his Memoir on the Refining of Lead in the large way, has given a sketch of the process used in England; if you think the following more detailed description will be acceptable to the readers of the Philosophical Journal, it is at your service.

The object of refining lead is not merely on account of the silver it contains, but to procure it as free as possible from the other metals with which it is usually alloyed, and to procure litharge. The silver is only an object so far as it helps to pay the expense of refining.

The lead produced at the smelting hearths or furnaces in England is never perfectly pure; it is always alloyed with a portion of silver, and most commonly with one or most of the following metals; namely, zinc, antimony, copper, and arsenic; which render it unfit for some of the purposes to which lead is applied.

The operation of refining is founded on the facility with which lead is oxidated when exposed to heat in contact with atmospheric air, and the peculiar properties the oxides of lead possess; being easily fused, and in that state oxidating and combining

* Nicholson, vol. 15, p. 1.

with most of the metals; gold, silver, and platina excepted.

The lead to be refined is exposed to the action of heat and air upon a *cupel* or *test*, composed of a mixture of bone and fern ashes in a reverberatory furnace; the description of which, with the different manipulations, are as follows:

The refining furnace is composed of good solid masonry, bound together with iron bolts. It differs very little in its construction from the common reverberatory furnace, except the bottom, which is perforated to receive the test or cupel.

Fig. 1, plate 14, is a perspective view of the furnace with its iron work; *a* the teazing hole, *b* aperture by which the test is supplied with lead, *c* an arch or dome over the feeding hole, communicating with the furnace stack by a flue, *d* area or space where the test is taken in and out the furnace, *ee* two strong iron bars to support the test when in its place, *f* cast-iron pot set in masonry, the flue passing into the stack of the furnace, *g* the stack, *p* the ash pit, *q* an iron bar to slide the ladle on when feeding the test.

Fig. 2, a perpendicular section of the furnace showing the test *i*, supported in its place under the opening of the bottom of the furnace by the two wedges *rr*; *k* aperture for the nozzle of the bellows, *s* fire bar resting on the bearers.

Fig. 3, plan of the interior of the furnace; *l* part of the bellows, *hh* flues from the body of the furnace to the stack.

The same letters in the different plans are meant to denote the same parts.

Plate 15, fig. 1, plan of the iron frame into which the mixture of bone and fern ashes is rammed to form the test.

Saddlers furnace for smelting lead.

Fig 1.

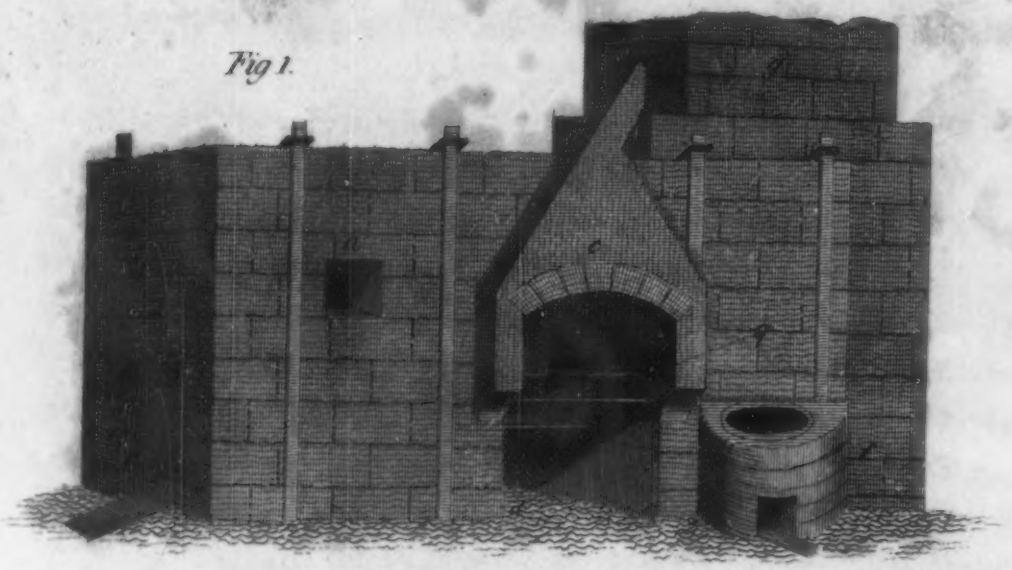


Fig 2.

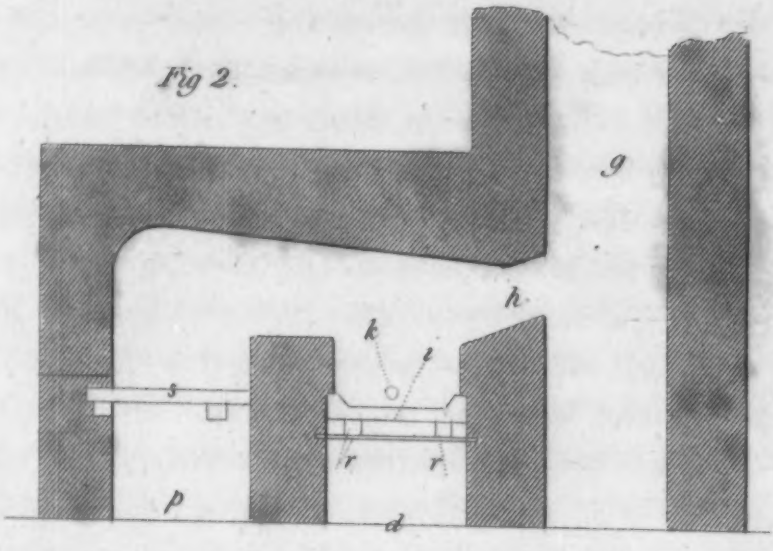
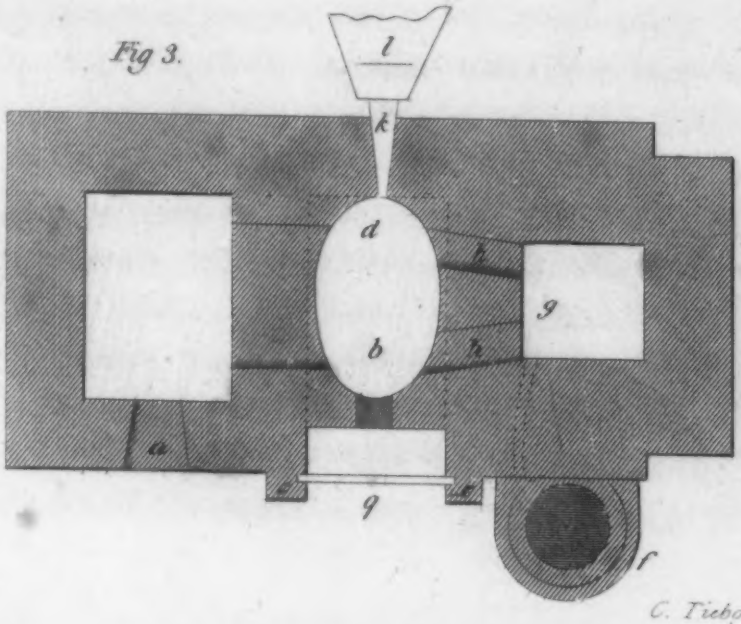


Fig 3.



C. Tiebout.

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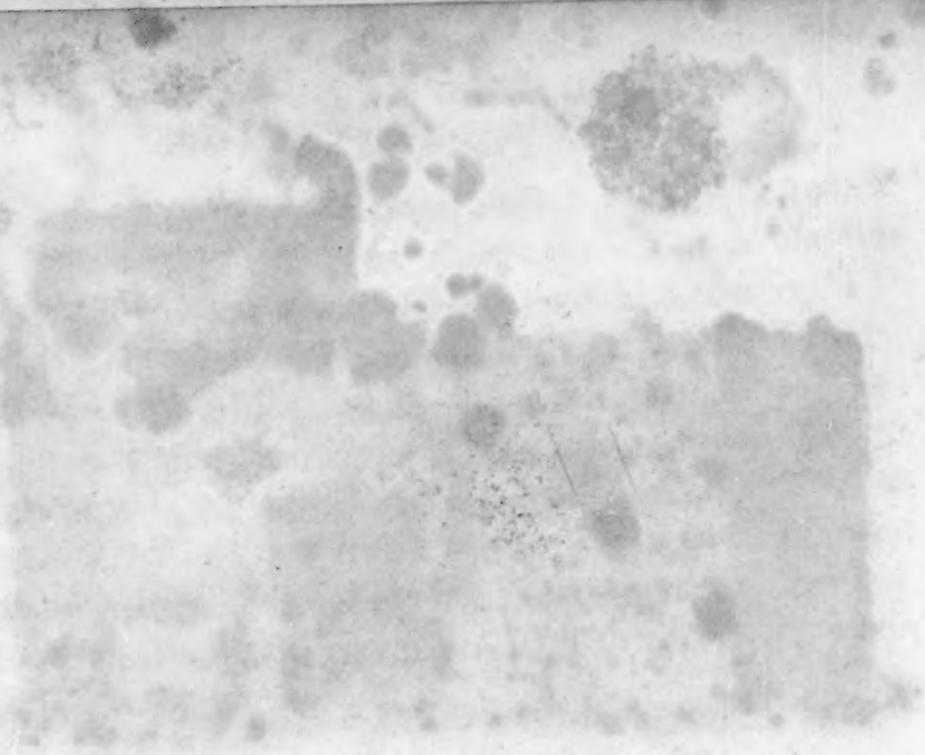


This frame is something larger than the elliptical hole in the bottom of the furnace.

Figs. 2 and 3, plan and section of the test; *m* the part which contains the lead to be refined, *n* breast of the test, *oo* small gutters or channels through which the litharge flows, *p* a semi-eliptical hole for the litharge to fall through from the gutters upon the area of the refinery.

These drawings and references will be sufficient to make the description of the furnace, &c. clearly understood.

Of the Test or Cupel.

A GOOD test is of the first importance in refining; the method of constructing one I shall endeavour to point out. Six parts of well burnt bone ashes and one part of good fern ashes are to be well mixed, sifted through a sieve, (the spaces in which are about one-eighth of an inch square,) and moistened to about the same degree the founders use their sand. The iron frame is to be laid on the floor and made steady, with wedges under its rim; about two inches in thickness of the ashes are to be equally spread over the bottom, and with an iron beater, such as used by the founders, equally rammed between the cross bars; the frame is to be again filled and rammed all over, beginning at the circumference and working spiral ways until finished in the centre, the filling and ramming to be repeated until the frame is completely full; an excavation to contain the lead is made as expressed in the plan, with a sharp spade about five inches square, the edges dressed with a long-bladed knife; a semi-eliptical hole, as at *p*, is to be cut through the breast. Having proceeded so far, the test is to be turned on its side and dressed from all superfluous ashes adhering to the bottom, taking care that none

shall be left flush with the bottom of the frame or cross bars, otherwise in fixing the test to its situation at the bottom of the furnace it would be liable to be bulged.

Fixing the Test in its situation.

THE rim of the test is now to be plastered with clay or moistened ashes, placed upon the supporting cross bars, and fixed with wedges firmly against the bottom of the furnace, the breast next to the feeding hole.

A gentle fire may now be lighted, and gradually increased until the test be red hot. When it ceases to emit steam from the under side it is sufficiently dry.

Lead previously melted in the iron pot *f* is ladled into the test until the hollow part be nearly filled, the operator closes the feeding aperture, and increases the heat of the furnace until the surface of the lead is well covered with litharge; he then removes the door from the feeding hole, and with an iron rod, which has one end bent down at right angles about three inches and made flat or chissel-shaped, scrapes the small gutter or channel *o* until the litharge just flows into it, the blast from a pair of double bellows is then directed from the back part over the surface of the test, the litharge is urged forward, and flows from the gutter upon the floor of the refinery; the operation now goes forward, gradually adding lead as the escape of litharge makes necessary, until the gutter is so worn down that the test does not contain more than an inch in depth of lead, the blast is then taken off, the gutter filled up with moistened ashes, and a fresh one made on the other side the breast; the test is again filled, though not so full as at first, and the operation carried on until this gutter also is worn down and the

test contain from about fifty to seventy pounds of alloy. This quantity is run into an iron pot, and set by until a sufficient number of pieces have been collected to make it worth while to take off a plate of pure silver from them.

The quantity of alloy left in the working off each test must depend in a great measure upon the quantity of silver it by estimation is supposed to contain. A sufficient quantity of lead should always be left in the alloy to make it fuse easily in the iron pot.

When the test is removed from the furnace and broken up, the litharge will be found to have penetrated to an inconsiderable but equal depth in the ashes; that part not impregnated with litharge may be pulverised, mixed with fresh ashes, and again used for another test.

The operation of taking off the silver pure differs in no respect from the foregoing, only more care is observed in the working, not to suffer the escape of any metallic particles with the litharge, as that would occasion considerable waste of silver. As the process advances, and the proportion of silver to lead increases, the litharge assumes a darker colour, a greater heat becomes necessary, and at last the brightening takes place; the interior of the furnace, which during the whole of the process had been very obscure and misty, clears up. When the operator observes the surface of the silver to be free from litharge, he removes the blast of the bellows, and suffers the furnace to cool gradually; as the silver cools many protuberances arise on the surface, and fluid silver is ejected from them with considerable force, which falling again on the plate spots it very fantastically with small globules.

The latter portions of litharge bring over a considera-

ble quantity of silver with them; this is generally reduced by itself and again refined.

The litharge as it falls upon the floor of the refinery is occasionally removed; it is in clots at first, but after a short time as it cools it falls for the most part like slacked lime, and appears in the brilliant scales it is met with in commerce: if it is intended as an article for sale, nothing more is necessary than to sift it from the clots which have not fallen and pack it in barrels.

If, on the contrary, it is intended to be manufactured into pure lead, it is placed in a reverberatory furnace, mixed with clean small-coal, and exposed to a heat just sufficient to fuse the litharge. The metal as it is reduced flows through an aperture into an iron pot, and is cast into pigs for sale. During the reducing, care is taken to keep the whole surface of the litharge in the furnace covered with small-coal.

In some smelt works, instead of a reverberatory furnace for reducing, a blast furnace is made use of, on account of the greater produce, but the lead so reduced is never so pure as that made in the wind furnace. The oxides of the metals, which require a greater heat to reduce than the lead, are in the blast furnace generally reduced with it.

The volatile oxides, as zinc, antimony, and arsenic, are mostly carried off by evaporation during refining; a considerable portion of the oxide of lead itself is carried off by evaporation, making the interior of the furnace so misty and obscure that a person unused to refining cannot see more than a few inches into it.

A considerable portion of these oxides are driven by the blast of the bellows through the feeding aperture, and would be dissipated in the refining-house, to the great injury of the workmen's healths; to prevent

their ill effects the arch or dome over the feeding hole is erected to carry the fume into the stack of the furnace.

No. 90.

*Description of Mr. G. Atkins's Hydrometer for determining the Specific Gravity of both Solids and Liquids.**

(With an engraving.)

SIR—The present improved state of chemistry; its application to so many of our principal manufactures, and the necessity of determining the specific gravity of the various substances which are used in them, or affording in all cases an important indication with regard to their qualities, and being in many the only accurate measure of their value, may perhaps render the following description of an instrument for this purpose not unacceptable to your numerous readers.

By giving it a place in your valuable Magazine you will therefore oblige yours, &c.

George Atkins.

To Mr. Tilloch.

Fleet Street, September 10, 1808.

The specific gravity, or comparative weight of the majority of those substances which fall under the observation of the manufacturer, the mineralogist, or the chemist, having always been considered as one of their most distinguishing characteristics, a variety of methods

* Tilloch, vol. 31, p. 254.

have at different periods been resorted to for ascertaining it.

In point of accuracy, perhaps, the best mode of taking the specific gravity of a body is by a very good hydrostatic balance. This instrument, however, we may venture to affirm, can scarcely ever be obtained sufficiently perfect to be depended on for so nice a purpose.

Persons who are in the habit of adjusting balances, and those who use them with considerable care, well know the various sources of error to which they are liable. The circumstance of the arms of a beam being in equilibrio, is no proof of its correctness, unless it will remain so when either loaded or unloaded, and with exchange of scale-pans. The necessity of having a piece of steel for the beam which shall be perfectly homogeneous; the uncertainty with regard to the exact equality of the arms, in both weight and length; and, even when very nicely adjusted, its liability to acquire polarity, and consequent derangement by magnetism; the expansion of either arm by the heat of the hand, or its contraction by a current of air, renders those instruments extremely liable to give anomalous results.

But supposing the balance not liable to error, it is too complicated in its use for any other than the man of science, in his closet, where time and close attention may be afforded; and since the application of science to the arts has become so general, chemists, manufacturers of acids, brewers, dyers, distillers, and all others whose manufacture consists of any cheminal process, require a more simple and expeditious mode of ascertaining the specific gravity, and consequently the value of their articles, than by the hydrostatic balance. Indeed, in many concerns its use would be impracticable, it being necessary to intrust the business of examining the qualities of the

substances in question to persons who have neither time or knowledge sufficient to enable them to apply an instrument of such a kind.

The *hydrometer*, on a variety of constructions, has been long made use of by distillers and all dealers in spirituous liquors; and of late years brewers have generally adopted it, for its simplicity and facility in use compared with the hydrostatic balance or weighing bottle. But as the hydrometer for spirituous-liquors, and the saccharometer for malt-liquors, (which the author of this paper is in the habit of manufacturing,) are adapted solely to their respective purposes, he has long thought it a very desirable object to construct an instrument which would combine *simplicity* with an universality of application to all substances, fluid and solid, of which it might be requisite to ascertain the specific gravity. And it is presumed that this object is accomplished in the instrument about to be described.

Among the principal subjects of consideration in the construction of hydrometers, are, the form of the instrument which shall be best adapted to facilitate its motion in a fluid, and that it be of a convenient size, both for the sake of portability, and that it may require as small a sample of a fluid as possible to make an experiment with.

With these views, the spheroidical form is that which has been preferred for the bulb of this instrument, on account of its more readily dividing the fluid in its passage up and down; and the size of it is such, that half a pint of any liquid is sufficient for trial with it.*

The hydrometer (see plate 15, fig. 5) consists of the bulb *b*, a small stem *a c*, with a cup *d* on its top to receive weights, and a shank *e f* beneath the bulb with a pointed screw, to which is affixed a cup *g*, to receive weights

* The figure in the engraving of the Emporium is half the size of the original drawing.

or solids when their specific gravities are required to be taken.

The instrument is accompanied with an accurate set of grain weights.

The weight of the hydrometer itself is seven hundred grains, and on adding three hundred grains in the *upper cup*, and immersing it in distilled water, at the temperature of 60 degrees of Fahrenheit's thermometer, it will subside to the middle mark on the stem, and will then consequently displace one thousand grains of water.

It follows, therefore, from this adjustment of the bulk of the instrument, that each grain in the upper cup will represent one thousandth part of the specific gravity of the water, or one unit in specific gravity, if that of water be taken to be one thousand; and one-tenth of a grain one-tenth of unit, which is also the value of each of the small divisions on the stem; and accordingly, when the hydrometer is immersed in any liquid until it sinks to the middle point on the stem, the specific gravity of such fluid will be indicated by the sum of the weight of the instrument (which is, as before stated, seven hundred grains) and the grains added in the upper cup.

Suppose, for example, that, on immersing the instrument in ether, it requires thirty-four grains in the top cup to make it subside to the middle mark on the stem. The specific gravity of such ether will in this case be $700 + 34 = .734$. And on putting the instrument into alcohol or wort, if it requires in the former case one hundred and twenty-five grains, and in the latter three hundred and fifty-five, the specific gravity of the spirit will be .825, and that of the wort 1.055.

To ascertain the specific gravity of a solid, we have to take any fragment less than three hundred grains; find its weight in air, and its weight in water, and take

Smelting of Lead.

Fig 1.

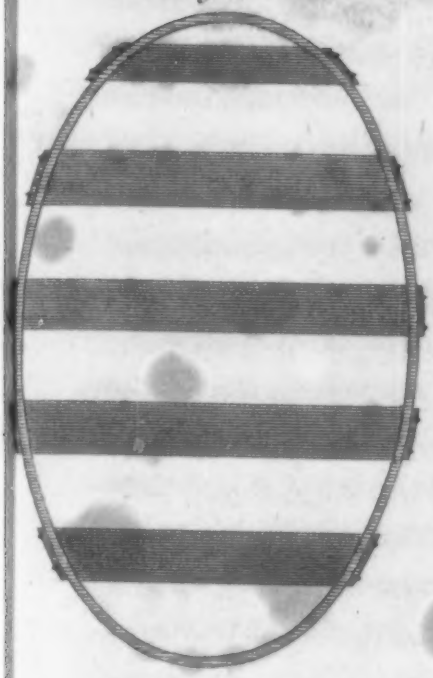


Fig 2.

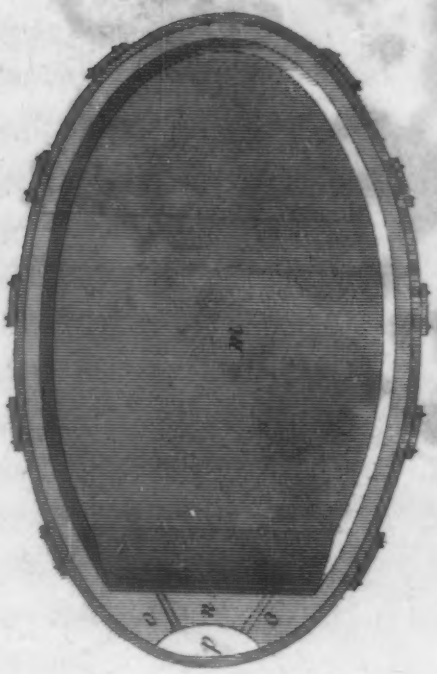
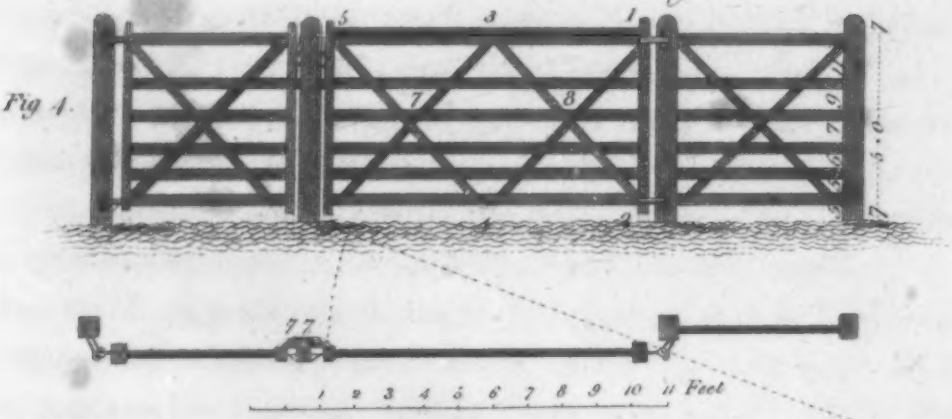


Fig 3.

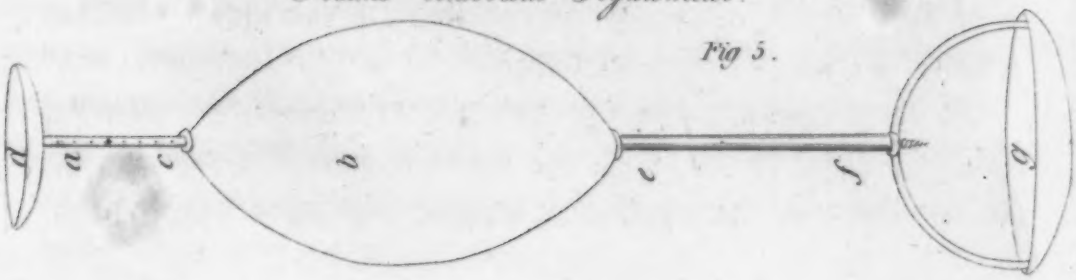
Waistell's Improved Field Gate.

Fig 4.



Atkins Universal Hydrometer.

Fig 5.



C. Tiebout

Emporium of Arts & Sciences Vol. 2. pl. 15.

their difference; and on dividing its weight in air by this difference the quotient will be its specific gravity.

The weight of a body in air is found by putting it in the *upper cup*, and adding grains until the hydrometer sinks in water to the mark on the stem. Now, as the substance and the additional weights in the cup will be altogether three hundred grains, the weight of the body will of course be so many grains as the weights put in fell short of three hundred. Its weight in water will be found by putting it into the *lower cup*, and adding grains in the *upper cup* until the instrument sinks as before: the complement of the weights in the top cup to three hundred being in like manner its weight in water.

Example.

If a body weighs in air one hundred and twenty grains, and in water one hundred and four, the difference is sixteen. On dividing one hundred and twenty by sixteen, we have for the quotient .75, or (taking, as before, the specific gravity of water at one thousand) 7.500 for the specific gravity of the body.

This instrument affords us consequently a very ready way of determining the purity or value of any alloy or metallic ore, and is therefore particularly adapted to the mineralogist. Thus, for example, the weight of a guinea, or its weight in air, is one hundred and twenty-eight grains; and if the gold is of its proper standard, it will weigh about one hundred and twenty-one grains in water, or will lose one-eighteenth part *only* of its weight in air. If it loses more, therefore, it is not of its proper specific gravity, and consequently not of standard gold.

To find the specific gravity of any of the different species of wood or other bodies lighter than water;—

after taking its weight in air as before, fix it on the small screw of the shank, and see how many grains it will then be necessary to add in the top cup, to sink the instrument to the mark, with the body on the screw; which will in this case be more than three hundred, on account of its buoyancy; and dividing its weight in air by the difference between the weights put in the top cup in each case, the quotient will be its specific gravity.

Thus, if on putting a piece of *willow* in the upper cup, it requires two hundred and fifty-eight grains to sink the hydrometer in water, the weight of the wood in air will be forty-two grains; and if on fixing it to the screw beneath, the instrument requires three hundred and twenty-eight grains to sink it to the mark in water, (being twenty-eight grains more than would be necessary to sink the instrument itself,) we have only to find the difference between the weights put into the top cup, which in this case is seventy grains; and dividing forty-two by seventy, we have .6 or .600 for the specific gravity of the wood.

For the man of science, the instrument with its set of weights is all that is necessary, and it is packed into a very small compass;* but to accommodate it to those who are concerned with spirituous liquors, and to brewers, the inventor attaches a scale, showing the relation between specific-gravities and the commercial or technical denominations of *per centage* with the former, and *pounds per barrel* with the latter.

It is needless to enumerate the various departments in which an attention to the specific gravities of bodies is now become of the first consequence, and wherein this instrument might be applied with advantage; and although many may be satisfied if they have any arbitrary stan-

* The price of it is five guineas.

dard to regulate their process by, yet it must be acknowledged that the universal standard of *specific gravity* is by far the best; for, by its currency all over Europe, it enables a person to know what relation their practice may bear to that of others in the same pursuit; and it would, by the universal adoption of it, prevent the many differences which exist among mercantile men, especially those who deal in, or pay duty on, spirituous liquors.

Indeed the wide field which opens, on considering the importance of paying attention to the specific gravity of bodies, convinces us that we are yet in infancy on the subject.

No. 91.

Description of an improved Gate for Fields. By Mr. Charles Waistell.*

(With an engraving.)

DEAR sir—The various methods used in bracing common gates for fields, prove that not one of them is greatly superior to the rest; for, if it was, that method would have been generally adopted. Most gates are loaded with superfluous timber in some of their parts, and are constructed upon such bad principles, that they are frequently broken by their own weight, aided by the concussion of the head against the falling-post; and this, long before any part of the wood has begun to decay. I have for some time given this subject considerable attention, being impressed with the idea, that if common

* Nicholson, vol. 11, p. 23. Communicated in a letter to Charles Taylor, Esquire, Secretary of the Society of Arts, who returned their thanks for the same.

gates could be constructed with less timber, and upon better principles, the saving of timber only would be of national importance; for we have many millions of gates to uphold in Britain, and their numbers are annually increasing. The result of my labours has been the plan which accompanies this letter. Gates made according to it, possess great strength, are very light, and of easy and simple construction. Although uniformity of appearance be not essential in a common gate, yet is worth having when it can be obtained, as in this gate, without additional expense.

My gate is made with short, and consequently less valuable, oak or ash timber, than those of the commonest construction; its strength is much greater than any other gate made with a like quantity of timber, there being at four distant points between the head and the heel, two bars and a brace crossing each other: and I doubt not that it will be found proportionably more durable: it is, besides, very easy to construct, and requires less labour than most other common gates. Twenty-nine years ago I designed plans for ornamental gates, with semi-oval and semi-circular braces, and had them executed; the plans were sent to my friends in various distant parts of this kingdom, as also to Ireland; and I have the pleasure to observe, that they are become almost the only ornamental gate in many parts of England. The plans of them I never published, although they were prepared for engraving fifteen years ago; and I should be as indifferent about my present design, of a common field gate, if I did not conceive that its publication would materially benefit the public; the introduction of this form being, I conceive, of some national importance, as timber has been lately greatly enhanced in price, and is rapidly on the advance.

This gate was designed for the approach to a country residence; but for common purposes, the wicket on one hand, and the short length of rails on the other, may be omitted. I shall thank you, if you will have the goodness to lay my plan before your respectable Society, of which I have, for many years, had the honour to be a member. And should this plan be approved of, I may probably furnish some designs for park gates on an improved construction. I am, &c.

CHARLES WAISTELL.

March 22, 1803.

To Mr. CHARLES TAYLOR.

Reference to the Engraving. Plate 15, *Fig.* 4.

DIMENSIONS.

THE heel of the gate to be about $3\frac{1}{2}$ inches square.
The head of ditto . . $2\frac{1}{2}$ by 3 inches.
The top rail or bar . . $3\frac{1}{2}$ by $1\frac{1}{2}$ inches.
The bottom bar . . . $3\frac{1}{2}$ by $1\frac{1}{4}$ inches.
The bar in the middle of the gate 3 by $1\frac{1}{4}$ inches.
The other bars, and the 4 braces $2\frac{1}{2}$ by $1\frac{3}{4}$ inches.

Observations on its Construction.

THE head and heel of the gate may be of oak, and the bars and braces of fir. Narrow and thick bars, when braced as in this design, are stronger than broad and thin ones, containing the same quantity of timber, and they also oppose a less surface to the wind. The two points in the heel of the gate, to which the thimbles are fastened, may be considered as firm or fixed points. From these points, namely, 1 and 2, two braces to proceed to 4 and 3, in the middle of the bottom and top bars, and being there secured, these become fixed points, and from these two points, namely, 4 and 3, two braces proceed to

5 and 6, fixing those points. The gate is thus doubly braced, namely, from the top of the heel to the top of the head, by means of the braces 1, 4, and 4, 5; and from the bottom of the heel to the bottom of the head, by means of the braces 2, 3, and 3, 6. On each side of the gate are two braces, and those parallel to each other. The brace proceeding from the bottom of the heel of the gate, and that which is parallel to it, as also the bottom bar, all strained in the way of compression, and the brace proceeding from the top of the heel, and the other brace which is parallel to it, and also the top bar, are all strained in the way of extension. The strains in this gate being none of them transverse, but all longitudinal, it would support a vast weight at its head without having its form altered. The braces all serve the double purpose of keeping the gate in its true form, and of shortening the bearings of the bars, and strengthening them. Few gates have less timber in their braces; and perhaps in no other way can a gate be so firmly braced with so small a quantity of timber.

At 3, 4, 7, and 8, two braces and a bar of the gate are firmly screwed together by means of iron pins and screw nuts. At the other points, where only one brace crosses a bar, common gate-nails are used.

If, in some cases, a strong top-bar be wanted, to resist the pressure of heavy cattle, a bar or board, about six inches broad, and one inch thick, may be laid with its broad side upon the top bar, and fixed thereto by means of the ends of the braces in the middle, and by the heel and head of the gate at the two ends of it. This board will, in this position, resist exactly the same pressure as a thick top bar, three inches broad, by four inches deep, although it contain no more than half the timber.

In the ground plan, or horizontal section, fig. 7, represents a piece of wood, about four inches cube, pinned to

the falling post, a little below the catch, to stop the gate from swinging beyond the post: another stop near the ground may be useful.

When gates are hung to open one way only, their heels and heads generally rest against the hanging and falling posts; but when they are hung according to this design, gates may be made about one foot shorter for the same opening, and consequently they must be lighter, stronger, and less expensive.

Of the hanging of Gates.

When the two hooks in the hanging-post are placed in the same perpendicular line, a gate, like a door, will rest in any direction in which it may be placed. But, in order that a gate may shut itself when thrown open, the hooks are not placed exactly perpendicular; the upper hook declining a little towards the falling-post, or a few feet beyond it. In whatever direction that hook declines the farthest, in the same direction will the gate rest, if unobstructed, and its head cannot then sink any lower. Make the head describe half a circle, and it will thus have attained its utmost elevation, and will be equally inclined to descend either to the right or to the left.*

The following method of fixing the hooks and thimbles, will, I think, be found to answer very well for a gate that is intended to open only one way. Supposing the face of the hanging-post to be set perpendicular, and the upper hook driven in near its inner angle, as is represented in the preceding design, and that the lower hook must be four feet and a half below it; suspend a plumb-line from the upper hook, and at four feet and a half mark the post; then at one inch and a half farther from

* See Chap. 2, of Mr. Parker's Essay on the Hanging of Gates; and also the Agricultural Report for Northumberland, by Messrs. Bailey and Culley.

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the gateway than this mark, drive in the lower hook; this hook must project about half an inch farther from the face of the post than the upper hook. In the section or ground-plan of the gate, the two white circles near the hanging-post represent the places of the two hooks when brought to the same horizontal line; that nearest the gateway represents the place of the upper hook. A line drawn through the middle of these two circles, and extended each way, will, on one hand, represent the gate's natural line of rest, and, on the other, the line of its highest elevation. A gate thus hung will, when thrown open nearly to the line of its highest elevation, return to the falling-post with a velocity sufficient to resist a moderately strong wind. This velocity will be either increased or diminished, accordingly as the upper hook declines more or less from a position perpendicular to the lower hook. In order to adapt the thimbles to these hooks;—as the lower hook is one inch and a half farther from the gateway than the upper hook, the lower thimble must have its eye an inch and a half farther from the heel of the gate than the eye of the upper thimble, in order that the bars of the gate may be in a horizontal position when it is shut. And, as the upper hook projects half an inch less from the hanging-post than the lower hook, the upper thimble should be fixed half an inch nearer the farther side of the heel of the gate than the lower thimble, in order that the gate may be in a perpendicular position when shut. If the thimbles have straps embracing the heel of the gate, and proceeding a few inches along each side of the bottom and top bars, and if they are fixed to the heel bars and braces, by means of iron pins and screw nuts, great firmness will be given to the gate at those two points, which are those that suffer the greatest strains.

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